SLIDING RULE.

Gift of M. B. Jones
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INSTRUMENTAL CALCULATION:

OR A TREATISE ON THE

SLIDING RULE,

COMPRISING EVERY THING NECESSARY FOR A FULL UNDERSTANDING OF THE NATURE AND USE OF THAT

INSTRUMENT,

AND ADAPTED TO THE READY COMPREHENSION OF THE MECHANIC, MERCHANT, AND FARMER, FOR WHOM IT IS DESIGNED.

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PREFACE.

In presenting the following pages to the public, the Author would observe that the object of them is to explain in a clear and intelligible manner, and illustrate by examples drawn from various sources, the nature and application of the Sliding Rule as an instrument of calculation, rather than to collect a mass of mechanical and arithmetical problems with their several solutions, which could be of no real benefit to any. In doing this, he has endeavored, as far as practicable, to present the examples and illustrations in a systematic order, commencing with the more easy, and rising to the most intricate, progressively developing the use of the instrument by thus applying it to the solution of various interesting and instructive problems in Addition, Subtraction, Multiplication, Division, Fractions, Rule of Three, Land, Board, Wood and Timber measure, Weighing, Prisms, Cylinders and Globes of Brass, Copper, Zinc Tin, Iron, Steel and Wood; in Mechanics, Gearing &c. &c. and thus, by not confining it to a particular channel, but teaching the principles of its operation, making it meet the wants of all who avail themselves of its peculiar benefits.

It will be unnecessary to speak here of the merit of the Sliding Rule, since its inventor, by it, obtained a celebrity and a name that will live while the mechanical arts continue to be cultivated, but it may be remarked, for simplicity, for exhibiting the several relations of the several quantities in a calculation clearly, and for expedition of opera-

tion, it is unequaled by any popular mode of calculation now in use. In giving this volume to the public the author is persuaded that he is making, if not an acceptable at least an useful offering.

MIDDLEBURY, October 14, 1846.

INTRODUCTION.

"MATHEMATICS, says Dr. Day, is the science of quantity, and quantity is anything which can be multiplied, divided, or measured;" hence there are but very few arts and sciences in which the principles contained in Mathematics are not employed to a greater or less extent; among which may be reckoned Astronomy, Navigation, Surveying, and the Mechanic Arts; in all of these and some others in which mathematical principles are employed, the operations in general become long and tedious. To obviate these difficulties much time has been spent, and various methods devised, the most expeditious of which (and consequently the best) is the construction of Tables, by means of which simplicity is united with brevity, and the long and difficult task becomes a pleasant and agreeable employment.

Of the multitude of such tables none have rendered more essential aid to man than the Logarithms. They were invented by Lord Napier, an eminent Mathematician of the seventeenth century, "and (says a distinguished writer) is properly considered as one of the most useful and excellent discoveries of modern times."

In order that they might be rendered more convenient and practical, Mr. Edmond Gunter, an ingenious mathematician, contrived a plan to represent the logarithms of numbers by lines drawn upon a rule, thus furnishing a very ingenious and expeditious mode of solving instrumentally many mathematical problems. This rule is variously modified to make it more convenient for particular purposes; but the line of Logarithms, or Numbers, as they are called, remain the same on every kind of rule. Those in common use have a Slider, which is contrived so as to answer the purpose of a pair of dividers, which otherwise would have to be used; and all rules made thus are called by the general name of Sliding Rule These in turn receive the name of the particular art or science to whic- they are adapted, thus: there are the Common Sl-

Rule, the Engineer's Rule, and the Ship Builder's Rule, respectively; which only differ in a table of guage points, or the situation of the different lines of numbers drawn upon them, to make them better suited to the particular arts in which they are employed.

The learner will be not a little surprised to find himself introduced to a mode of reckoning entirely new in its nature and novel in its operations, affording many facilities of calculation unknown in common Arithmetic, at the same time forming an excellent mental exercise, which, if no other advantage was derived, would fully compensate for his labor.

DESCRIPTION OF THE COMMON SLIDING RULE.

This Rule consists of two pieces of box-wood, each a foot long, fastened together with a joint on which they turn, forming, when extended at full length, a two foot rule, not unlike the common rule used by carpenters, and like it, is divided, on one face into inches and parts, thus answering every purpose of that instrument. The edges are divided, like the Parisian foot, into tenths and hundredths, and are very convenient in taking dimensions to be used on the Rule.

On the other face are the lines of numbers, part of which are drawn upon the slider and part upon the fixed part, and are marked with the letters A, B, C, D, to distinguish them from each other, and are called the A line, B line, &c. The three first are exactly alike, and are numbered from left to right with the figures 1, 2, 3, 4, 5, 6, 7, 8, 9—1, 2, 3, 4, 5, 6, 7, 8, 9, 10, which are called *primes;* these are again divided from 1 to 2 into fifty parts, from 2 to 3 into twenty, and the others, from 3 to 9, into ten respectively. Below these, on the same leg, is the D line, also marked *girt line:* it is of a single radius double the length of those above, the principal divisions of which

commencing at the left, are numbered 4, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 40; having twenty subdivisions between 4 and 5, forty between 10 and 20, and twenty between each of the others. On the other leg is a drawing scale of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 inch to the foot.

NUMERATION.

The next thing, or rather the first thing to be learned, is Numeration, which should be *perfectly* understood to ensure success to the learner. The first thing to be observed is that the numbers and divisions of the different lines are all arbitrary, but they always have the same value at the same distance from unity, and all the divisions increase and decrease in a ten-fold proportion:—thus, if the 1 in the middle of the Rule be called a unit, then the next long division marked 2 will be two units or two, and the 3 three, &c. to 10 at the end; and the 9 on the left of the middle 1 will represent nine-tenths, and the 8 eight-tenths, &c., and the subdivisions represent hundredths and thousandths; that is, if the primes, being units, are divided into ten parts, each of these parts represent one-tenth, and if they are divided into one hundred parts, each part would represent one-hundredth; and the like subdivision on the left of the middle 1 will represent hundredths and thousandths, the primes be-

ing tenths. If the 1 next the joint represent unity or 1; then the middle 1 represents 10, and the 10 at the end 100, and the primes of the first rudius (that is from the 1 next the joint to the 1 in the middle) represent units, and the subdivisions (that is, those between them) tenths and hundredths respectively; the primes of the second radius (that is, from the 1 in the middle to the 10 at the end) represent tens, and the subdivisions units and tenths. If the 1 next the joint represents ten, then the middle 1 will represent one hundred and the 10 at the end one thousand, thus always increasing in a ten-fold proportion; and the primes and subdivisions increase in the same ratio.

Whenever it is necessary to continue the numeration beyond what the 10 at the end would express, it can be done by going back to the 1 next the joint and let that represent what the 10 at the end represented, then proceed as before, and in this way it can be continued without limit.

Examples.

1. Suppose it is required to find the division representing the number 1500:—let the 10 at the end represent, (as above) 1000, then go back to the 1 next the joint and call that 1000, then will the long mark between 1 and 2 be the division sought.

2. Suppose it be required to find the division representing the number 25:—call the 1 next the joint one, then the 1 in the middle represents ten, and the division (to the right) marked 2 twenty,

then count off five of the long marks between 2 and 3 for the division sought.

3. Suppose it be required to find the division representing the number 2-10:—let the 1 in the middle represent unity or 1, then all the primes on the first radius will represent tenths; therefore the one marked 2, is the division required.

4. Suppose it be required to find the division representing the number 35-100; let the 1 in the middle represent unity or one, as in the last example, then the prime marked 3 in the left hand radius represents three-tenths or thirty-hundredths, and five of the long marks between 3 and 4 is the division sought.

5 Suppose it be required to find the number* 5-1000:—let the 10 at the end represent unity or one, then the 1 in the middle represent one-tenth, and the 1 next the joint 1-100, and each of the ten long marks or divisions between 1 and 2 represents, of course, 1-1000, then five of these will be the required number: or otherwise, go back to the 10 at the end and let that represent the number represented by the 1 next the joint, that is 1-100, then each of the primes in the right hand radius represents 1-1000, five of which will be the number sought.

6. Suppose it be required to find the number 230 upon this rule:—let the 1 in the left hand radius represent unity or one, then the 1 in the middle represents ten, and the 10 at the end one hundred; now let the 1 in the left hand radius repre-

* Number is generally used instead of the expression "division," and will be employed in the following pages instead of it.

sent one hundred as before directed, then each of the primes represent hundreds, and of course the division marked 2 represents two hundred, and two of the long marks or divisions between 2 and 3, each of which are tens, is the required number.

7. Suppose it is required to find the number 335: —let the 1 of the left hand radius represent unity, as in the last example, then the 10 at the end represents 100, and each of the primes of the left hand radius represent hundreds, therefore the division marked 3 represents three hundred, and each of the long marks between 3 and 4 represent ten, three of which is thirty, and half way between the third long mark and fourth long mark is five units, which will make out the required number, that is 335.

In this manner all numbers can be found to a sufficient degree of accuracy for common purposes. Now please turn back and read this over once or twice before you proceed farther, for it is on Numeration your success depends.

Note.—The above directions for Numeration on this instrument have been given for the double lines, because the principles could be more easily explained and illustrated on these than the single or girt line, and will apply equally as well to the latter as to the former.

ADDITION.

RULE.—First find the largest of the numbers to be added on either of the lines of numbers, as directed in numeration, and from this count off towards the right hand the next largest, and from this last the next; continue counting off in this manner until none remain, the last of which will show the sum or amount of the whole.

Examples.

1. What is the amount of 6, 8 and 12 added together? First find 12 on the A line, then count off from 12 towards the right hand, eight of the long marks between 12 and 2, and they will reach to 2 or 20, then from 2 count off six of the long marks between 2 and 3 and they will extend to 26 for the answer.

2. If a man receives in pay for a month's labor at one time $5, at another $7, and at another $9, how much does his labor amount to per month? From 9 in the left hand radius count off one prime and six of the long marks between 1 and 2, to that division last found count off four more long marks which will extend to 2, then one of the long marks between 2 and 3 will be the required number, that is $21 for the answer.

3. Suppose a man buys a house and lot and pays at one time $750, at another $625, how much does it cost him? Let the 1 next the joint represent 100, of course the prime marked 7 represents 700, and five of the long marks between 7 and 8 represent 50, consequently the fifth mark represents 750; from this count off three primes

which will extend to the middle 1, (1000,) from this count off three long marks between 1 and 2, and three of the short ones, if there are only four, between the 3d and 4th long ones, each of which is 15, (but six, if there are eight short ones, each of which is of course 12½,) for the division sought, and which represents $1,375.

1. If a man buy $2,500,000 worth of stock in a certain incorporation, and owned in the same previous to the purchase $1,600,000, what is the amount of his stock in the incorporation? Let the 1 in the left hand radius represent 1,000,000, then the prime marked 2 is 2,000,000 and five of the long marks between 2 and 3 represent 500,000, therefore the 5th division represents 2,500,000, from this count off one prime and six long marks which represent the amount, that is $4,100,000.

Note.—Decimals can be added in the same manner as whole numbers.

SUBTRACTION.

Subtraction may be defined the finding the difference between two numbers or quantities.

Rule.—Find the largest of the two numbers as in Addition, and from it count off towards the left hand the lesser, which will extend to the division denoting the difference.

Examples.

1. What is the difference between the numbers 65 and 40? Let the 1 in the left hand radius represent 10, then the fifth long mark between 6 and 7 represents 65; from this count off four divisions of ten marks each, which will extend to 25, that is, to the fifth long mark between 2 and 3.

2. What is the difference between 640 and 325? Let the 1 next the joint represent 100, then the fourth long mark between 6 and 7 represents 640; from this count off three divisions of ten long marks each, and two and a half long marks from the next division for the answer: or otherwise, count off from 640 thirty and a half long marks, which will extend to 315 as before.

3. If a man buys a farm for $8000 and makes one payment of $3400, what will there be due for the farm? Let the 1 in the left hand radius represent 1000, then the prime marked 8 represents 8000, from which count off three primes and four long marks, which will extend to 4600 for the answer.

4. If a man's labor for one year amounts to $550, and his expenses for the same time to $160, how much will he have after his expenses are paid? Let the 1 next the joint represent 100, then the fifth long mark between 5 and 6 represents 550, from which count one division and six long marks, which will reach to $390 for the answer.

5. A farmer from a flock of 215 sheep sells 40, how many remains? Let the 1 in the left hand radius represent 10, then the 1 in the right hand radius represents 100, consequently the prime

marked 2 represents 200, and of course one and a half long marks between 2 and 3 represents 215; from this count off four long marks or their equal, which will extend to 175, the answer.

6. A merchant had 105 pieces of cloth and sold 14 of them, how many had he left? Let the 1 next the joint represent 10 as before, then the one in the right hand radius represents 100, therefore the 1 in the right hand radius and the long mark towards the right represents 105; from this count off fourteen units, which extends to 91 for the answer.

6. A man owed a debt of 15s. 6d. of which he paid 7s., how much was then due? Here the 6d. is equal to 1-2 or 5-10, therefore from the division representing 15.5 count off seven units, which will extend to 11.5 for the answer.

MULTIPLICATION.

"Multiplication," (says Hutton,) "is a compendious method of addition, teaching how to find the amount of any given number when repeated a certain number of times: as 4 times 6, which are 24.

"The number to be multiplied or repeated, continues the same author, is called the *multiplicand*; the number you multiply by or number of repetitions is the *multiplier*, and the number found, be-

ing the total amount, is called the *product*. Also both the multiplier and the multiplicand are, in general, named the *terms* or *factors*."

Rule.—Bring the 1 on the line B to the multiplicand* on the line A, then against the multiplier on the line B will be the product on the line A.

Examples.

1. Multiply 8 by 6. Bring 1 on the line B to 8 upon the line A, and against 6 upon the line B is 48 upon the line A.

2. If a man travel 4 miles an hour how far will he travel at that rate in 9 hours? Bring 1 on B† to 9 upon A, and against 4 upon B is 36 upon A.

As the slider now stands the lines B and A are a table of rates. and miles traveled in nine hours; for against any rate per hour on the line A, is the number of miles traveled at that rate in 9 hours on the line B. Thus:

is	45	54	63	72	81	90	99	miles on A
ag'nst	5	6	7	8	9	19	18	miles per hour on B.

3. How much will 31 yards of calico come to at 12 cents per yard? Bring 1 on the line B to 31 on the line A, then against 12 on the line B will be 372 cents, or three dollars and seventy-two cents, on A.

4. How much will 15 tons of hay come to at $6 a ton? Bring 1 on the line B to 15 on the line A, and against 6 on the line B is $90 on A.

5. How much will a pile of wood containing

* The multiplicand is the number to be multiplied.

† The 1 in the right hand radius is preferable.

19 cords come to at $1 50 per cord? Bring 1 on the B line to 19 on the A line, and against 1,50 (that is against one and five-tenths, for five-tenths equals fifty-hundredths) on B. is $28 50.

6. If a family use 1-2 a pound of tea in one week, how much will it use in one year, or fifty-two weeks? Here 1-2 equals 5-10, consequently bring 1 on B to 5 (or to the fifth prime in the left hand radius,) on A, then against 52 on B will be 26 pounds for the answer on A.

7. If 1 lb. of tea costs 75 cents how much will 26lbs. come to at the same rate? Bring 1 on B to ,75 on A, and against 26 on B is 19,5, that is, $19 50 on A, for the answer.

8. How much will a piece of broadcloth containing 23 yards come to at $4 25 per yard? Bring 1 on B to 4,24 (that is, to two and a half long marks between the primes 4 and 5) on A, and against 23 on B is the answer $97 75, on A.

8. Multiply 25 by 15. Bring 1 on the line B to 35 on the line A, and against 15 on the line B is 525 on A.

As the slider now stands, a variety of questions and problems can be readily formed and solved, by varying the factors, that is, the value of them; thus, let the 35 represent 3,5, (three and five-tenths) and the 15 remain the same as in the last example, then the product will be 52,5; now let the multiplier represent 1,5, (one and five-tenths) and the multiplicand the same as in the last, then the product will be 5,25, (five and twenty-five-hundredths;) again, let the multiplicand represent ,35 [thirty-five-hundredths] and the multiplier the same as in the last, then the product will

be ,525, [five hundred and twenty-five-thousandths.] Now by changing the value of the factors to hundreds, &c. the products will be increased in the same ratio that they were decreased; thus—let 35 represent 350, and the multiplier remain 15, then the product will be 5250; if now you let the multiplier represent 150, and the multiplicand the same as in the last, the product will be 52500; again, if the multiplicand represent 3500, and the multiplier remain the same, then the product will be 525000. In this manner the operation can be carried on to almost any extent, and a great variety of results obtained without altering the position of the slider.

DIVISION.

Division is generally defined a "compendious method of Subtraction, teaching to find how often one number is contained in another, or may be taken out of it, which is the same thing."—*Hutton.*

In Division there are two parts given to find the third. "The number to be divided is called the *Dividend*, the number to divide by is the *Divisor*, and the number of times the dividend contains the divisor is called the *Quotient*."—*Hutton.*

RULE.*—Bring 1 on the slider to the divisor on the line A, and against the dividend on the line A will be the quotient or answer on the line B.

Examples.

1. Divide 16 by 4. Bring 1 on the line B to 4 on the line A, and against 16 on the line A will be 4 on the line B, for answer.

2. Divide 96 by 3. Bring 1 on the line B to 3 on the line A, and against 96 on the line A will be 32 on the line B, for answer.

3. If a chest of tea, containing 25lbs, costs $18 75, what is that per lb? Bring 1 on the line B to 25 on the line A, and against 18,75 on the line A is 75 cents on the line B, for answer.

4. If 12 cords of wood cost $18 how much is that per cord? Bring 1 on B to 12 on A, and against 5,18 on A is $1 50 on B, for answer.

5. If a piece of cloth containing 30 yards cost $3 60, how much is that per yard? Bring 1 on the line B to 30 on the line A, and against 3,60 on the line A is 12 cents on B, for answer.

6. If 360lbs. of sugar cost $32 40 how much is that per lb? Bring 1 on the line B to 360 on the line A, and against 32,40 on the line A is 9 cents on the line B, for answer.

* The rule for Division is usually given as above, and that for Multiplication as follows: bring the multiplicand on the line B to 1 on the line A, and against the multiplier on the line A will be the product, or answer, on the line B. But it seems more natural to bring the 1 on the slider to the multiplicand on the line A, as in multiplication, than to bring the multiplicand on the line B to 1 on the line A, as is usually done.

7. If 12 tons of hay cost $96, what is that per ton? Bring 1 on B to 12 on A, and against 96 on A is $8 on B, for answer.

8. What number must I multiply by 16 that the product may be 640? Bring 1 on B to 16 on A, and against 640 on A is 40 on B, for answer.

9. How many feet are there in 300 inches? Bring 1 on B to 12 [the number of inches in a foot] on A, and against 300 on A is 25 feet on B, for answer.

10. How many feet in 360 inches? Ans. 30.

11. How many in 3600? Ans. 300.

RULE SECOND.—Invert* the slider so as to bring the lines A and C together, and bring 1 on C to the dividend on A, then against the divisor on C will be the quotient on A.

By comparing the above rule with the first, it will be observed that this is more proper for division than that, since division is the reverse of multiplication.

Examples.

1. How many feet are there in a board containing 132 inches? Bring 1 on C to 132 on A, then against 12 on C will be 11 on A, for answer.

2. Divide 65 by 6. Bring 1 on C to 65 on A, and against 6 on C will be 10-8 on A. for answer.

3. Divide 65 by 5. Bring 1 on C to 65 on A, as before, and against 5 on C is 13 on A, for answer.

* That is, change ends of the slider, which is commonly called inverting it.

As the slider now stands the lines A and C are lines of quotients and divisors of the dividend 65, respectively—thus:

is	32,5	21,6	16,5	11,	10,8	9,3	8,2	7,2	6,5
ag'st	2	3	4	5	6	7	8	9	10

4. How many rods are there in 90 feet? Bring 1 on C to 90 on A, and against 16½ [the number of feet in a rod] on C is 5,45 nearly on A.

FRACTIONS.

To reduce Vulgar Fractions to their equivalent Decimals.

RULE.—Bring 1 on B to the denominator on A, then against the numerator on A will be the decimal required on B—or, invert the slider and bring 1 on C to the numerator on A, and against the denominator C will be the decimal required on A.

The nature of the above rules will be discovered when it is considered that the numerator and denominator of a fraction are nothing more than a dividend and divisor; consequently the decimal expression is the quotient obtained by dividing the numerator by the denominator, and the rules here given are the same as those in division, excepting the words numerator and denominator are used instead of dividend and divisor.

Examples.

1. What is the decimal equivalent to the vulgar fraction 3-4? Bring 1 on B to 4 upon A, and against 3 upon A is ,75 [seventy-five-hundredths] upon B, for answer.

Or, invert the slider, and set 1 upon C to 3 upon A, and against 4 upon C is ,75 upon A, the answer as before.

2. What is the decimal equivalent to the vulgar fraction 1-4? Set 1 upon B to 4 upon A, and against 1 upon A is ,25 [twenty-five-hundredths] upon B, for answer.

Or, invert the slider, and set 1 upon C to 1 upon A, and against 4 upon C is ,25 on A, the answer as before.

3. Reduce the vulgar fraction 1-25 [one-twenty-fifth] to its equivalent decimal. Let the slider remain inverted, as in the last example, and set 1 upon C, 1 upon A, and against 25 upon C is ,04 [four-hundredths] the answer, upon A.

4. What is the decimal expression equivalent to the vulgar fraction 1-5? Let the slider remain as in the last example, and against 5 on C is ,2 [two-tenths] upon A for answer.

From the examples here given to illustrate the rule, the nature of the operation will be clearly seen, therefore the addition of more will be unnecessary.

To find a reciprocal of any number,

That is, to find a number that shall perform the same by multiplication that a certain other number does by division.

Rule.—Set the given number or divisor upon

the line A to 1, upon the line B, and against 1 upon the line A will be the required multiplier on the line B.

From a careful examination of this rule it will be discovered that it is nothing more than dividing unity [that is, 1] by the given divisor.

Examples.

What is the reciprocal of 20? Set 20 upon the line A to 1 upon the line B, and against 1 upon the line A is ,05, [five hundredths,] the answer upon the line B.

Now by multiplying any number by ,05 the same result is obtained as if the given number had been divided by 20. Thus by dividing the number 400 by 20 as follows:

20)400(20
40
—
0

the quotient is 20; and by multiplying the same number, that is 400, by ,05, as follows,

400
,05
—
the product is 20,00 as before.

Thus the numbers 20 and ,05, as is seen in the above operations, are the reciprocals of each other.

2. What is the reciprocal of the number 25? Set 25 upon the line A to 1 upon the line B, and against 1 upon the line A is ,04 [four hundredths,] the number required, upon the line B.

3. What is the reciprocal of 40? Set 40 upon A to 1 upon B, and against 1 upon A is ,025,

[twenty-five-thousandths] upon the line B, for the answer.

4. What is the reciprocal of 4? Ans.,25.
5. What is the reciprocal of 5? Ans. ,20.
6. What is the reciprocal of 80? Ans. ,0125.
7. What is the reciprocal of ,7854? Ans. 12,73.

RULE OF THREE DIRECT.

Rule.—Set the first term upon the line B to the second term upon the line A, and against the third term upon the line B will be the fourth term, or answer, upon the line A.

Examples.

1. If 3 lbs. of tea cost 12 shillings, how much will 8 lbs. cost at that rate? By carefully examining this example it will be discovered that 3 is the first term, 12 the second, and 8 the third; hence, set 3 upon B to 12 upon A, and against 8 upon B is 32 shillings upon A, the answer.

2. If 8 lbs. of tea cost 32 shillings, how much will 3 lbs. cost? In this example it will be seen that more requires more, and that 8 is the first term, 32 the second, and 3 the third; therefore set 8 upon B to 32 upon A, and against 3 upon B is 12 shillings upon A, the answer.

3. If a man walk 10 miles in 3 hours, how far will he walk in 12 hours? In this example

3 is the first term, 10 the second, and 12 the third; therefore set 3 upon B to 10 upon A, and against 12 upon B is 40 miles, the answer, upon A.

4. If it take a man 3 hours to walk 10 miles, how long will it take him to walk 40 miles? Here 10 is the first term, 3 the second, and 50 the third; therefore set 10 upon B to 3 upon A, and against 40 upon B is 12 hours upon A, the answer.

As the slider now stands the lines A and B are lines of hours and miles respectively, for against any number of miles upon B will be the number of hours employed (at the given rate) upon A.

Thus, is	4,5	6	9	&c. hours upon A,
against	15	20	30	&c. miles upon B.

From these examples it will be seen that the first and third terms are of the same name, and the second and fourth are also of the same name; thus, as in the last example—10 miles : 3 hours :: 40 miles : 12 hours.* This must be carefully observed in stating questions in the Rule of Three.

5. If 5 bushels of oats can be bought for 9 shillings, how many bushels can be had for 45 shillings? Set 9 upon B to 5 upon A, and against 45 upon B is 25 bushels upon A, the answer.

6. If 5 bushels of oats cost 9 shillings, how much will 25 bushels cost? Set 5 upon B to 9 upon A, and against 25 upon B will be 45 upon A, the answer.

Remark.—Some prefer setting the first term upon A to the second upon B, and the third term up-

* Read thus: as 10 miles is to 3 hours, so is 40 miles to 12 hours.

on A to the fourth upon B. This mode of solving a problem does not alter the result of the operation, since the two lines of numbers used are exactly alike, but it is not so convenient in practice as the former here given; but either can be employed at the discretion of the operator.

7. If 3 paces of a certain person be equal to 2 yards, how many yards will 160 of his paces make? *Ans.* 106 yds. 2 feet.

8. If 750 men require 22,500 rations of bread for a month, how many rations will a garrison of 1200 men require? *Ans.* 36,000.

9. If 5 bushels of corn are worth $3 75, what is 16 bushels worth at that rate? *Ans.* $12.

10. What is 30 bushels at the same rate? *Ans.* $22 50.

RULE OF THREE INVERSE.

RULE.—Invert the slider and set the first term upon C to the second upon *A*, and against the third term upon C will be the fourth upon *A*.

Examples.

1. If 3 men dig a certain quantity of trench in 14 hours, in how many hours will 6 men dig the like quantity? The 3 is the first term, 14 the second, and 6 the third; invert the slider and set

3 upon C to 14 upon *A*, and against 6 upon C is 7 hours upon *A*, the answer.

2. If 6 men perform a certain quantity of work in 7 hours, in how many hours will 3 men perform the same? In this the first term is 6, the second 7, and the third 3; hence invert the slider as before directed, and set 6 upon C to 7 upon A, and against 3 upon C is 14 upon A, the answer.

3. If 4 men plane 250 deal boards in 6 days, how many men will it take to plane them in 2 days? Invert the slide as before directed, and set 2 upon C to 4 upon *A*, and against 6 upon C will be 12 upon *A*, the answer.

4. If a quartern loaf weigh 4,5 lbs when wheat is 5s. 6d. a bushel, what must it weigh when wheat is 4s. per bushel? Set 5,5 upon C to 4,5 upon *A*, and against 4 upon C will be 6,2 lbs. upon *A*, the answer.

The Rule of Three Inverse can be performed upon this instrument without inverting the slide, by setting the third term upon C to the first upon *A*, and against the second term upon C will be the fourth or answer upon *A*. Thus, taking the last example, for instance: place the slide in the proper way, and set 4 upon B to 5,5 upon *A*, and against 4,5 upon B is 6,2 upon *A*, the answer. But it is most natural to invert the slide and solve the question according to the rule, being more in accordance with the idea of inverse proportion than the mode here spoken of.

INTEREST.

Interest is an allowance made by a borrower of money to the lender, and is sometimes called "the premium or forbearance of money."

The money lent or forborn,e is called the Principal, and the Principal and Interest together is called the *Amount*.

Interest is computed at a certain proportion to the principal, that is, a certain number of dollars for every hundred, or a certain number of cents for every dollar for one year.

This proportion varies in different countries and States; thus, in England it is fixed by law at 5 cents for every dollar, or $5 for every hundred, and in New England at 6 cents for every dollar, or $6 for every hundred, while in New York and some other States at 7 cents to every dollar, or $7 for every hundred.

This allowance paid for the use of money is called the rate per cent.; thus, when money is lent in New England at lawful interest, it is said to be lent at 6 per cent., and in New York at 7 per cent. &c.

Rule—To find the interest of any sum of money at any given rate per cent.—Set 1 (dollar) upon B to the rate per cent. upon *A*, and against the given sum upon B will be the interest sought upon *A*. Or make the following statement in the Rule of Three Direct: as $1 upon B is to its interest upon *A*, so is the given sum to its interest for the same time.

Examples.

1. What is the interest of $500 for one year at 6 per cent? Set 1 upon B to ,06 upon *A*, and against 500 upon B is $30 upon *A*, the answer.

2. What is the interest of the same amount at 5 per cent? Set 1 upon B to ,05 upon *A*, and against 500 upon B is $25, the answer, upon *A*.

3. What is the interest of $500 at 2 per cent for one year? *Ans.* $10.

4 What is the interest of $63 for one year at 4 per cent? Set 1 upon B to ,04 upon *A*, and against 63 upon B is $2 52 upon A, the answer.

5. What is the interest of $63 for one year at 5 per cent? *Ans.* $3 15.

6. What is the interest of $25 25 for one year at 9 per cent? Set 1 upon *B* to ,09 upon *A*, and against 25,25 upon B is $2 26 upon *A*, the answer.

What is the interest of 96 cents for one year at 7 per cent? *Ans.* ,067.

Under the rule before given may be solved all such problems in which rate per cent is considered without regard to time.

Examples.

1. How much will a collector receive for his trouble in collecting a tax of $2,500 at 3 per cent It will be perceived that this does not differ from the examples before given; therefore set 1 upon B to ,03 upon *A*, and against 2500 upon B will be $75, the answer, upon *A*.

2. If I allow a certain person who assists me in selling goods to the amount of $7,620 4 per cent on the whole amount sold, how much will he receive for his trouble? Set 1 upon B to ,

on *A*, and against 7620 upon B will be $304 80 upon *A*, the answer.

3. If a factor buys goods for his employer to the amount of $5,250, and receives 2½ per cent for his services, how much will he receive? Set 1 upon B to ,025 upon *A*, and against 5250 upon B will be $131 25, the answer upon *A*.

The head under which the three last examples are included is called

COMMISSION.

Examples.

1. A correspondent purchases goods for his employer to the amount of $15,000, how much will he receive at a commission of 3 per cent? Ans. $450.

How much will he receive on the same at a commission of 4 per cent? at 2 per cent? at 2½ per cent? at 1½ per cent? at 6 per cent? Ans. to the last, $900.

Note.—1½ per cent, 2½ per cent, &c. is the same as 1 cent and 5 mills, 2 cents and 5 mills, &c., and when used upon this instrument (viz: the Slide Rule) are to be expressed decimally, thus; ,015, ,025, &c. It should be kept in mind that in reckoning dollars and cents, that dollars are considered as units or whole numbers, and the cents as decimals or parts of whole numbers.

2. If a factor purchases goods on my account to the amount of $25,000, and has a premium of 5 per cent, how much will it amount to in all? Set 1 upon B to ,05 upon *A*, and against 25000 upon B will be $1,250 upon *A*, the answer.

STOCK.

Stock is the name applied to the capital invested in a corporation or trading company, and is bought and sold at so much above or below *par*, (which is a latin word signifying equal;) which means if 100 cents worth of stock is sold for 112, it is said to be 12 cents above par; and if 100 cents worth of stock is sold at 88 cents, it is said to be sold 12 cents below par, &c.

Examples.

What is the value of $450 at 4 per cent above par? Set 1 upon B to 4 upon *A*, and against 450 upon B will be $18 upon *A*, which must be added to the 450 to find the amount sought, because that sum [18] is the amount of the per cent above par; but had the condition of the problem been at 4 per cent below par, then the 18 would had to have been subtracted from the 450, because the 18 would have been the amount of the per cent below par.

Or it may be solved thus: set 100 upon B to 104 upon *A*, and against 450 upon B will be $468 the answer required, upon *A*. Had the condition of the problem been at 4 per cent below par, the operation would be thus: set 100 upon B to 96 upon *A*, and against 450 upon B is $442, the answer, upon *A*.

From the principles exhibited in the solution of the above example, we may adduce the following

RULE.—Set 1 upon B to the rate per cent, or the advance, as it is sometimes called, upon *A*,

and against the stock upon B will be the amount of rate per cent, or advance, which is to be added to or subtracted from the stock, according as the advance, or per cent, is above or below par.

Or—Set 100 upon B to the rate per cent added to or subtracted from 100* [according as the rate per cent is above or below par] upon *A*, and against the stock upon B will be the amount of the stock and the advance required.

The first of the above rules is nearly the same as that given for interest, and may be included under that head. The second obtains at one operation the sum of the rate per cent on the whole stock and the stock, and is a simple statement in the Rule of Three; which is as follows: as 100 cents or dollars is to the sum or difference of 100 cents or dollars and the per cent on 100 cents or dollars, so is the given stock to the present value of the stock.

Examples.

1. What is the value of $225 at 3 per cent above par? Set 1 upon B to ,03 upon *A*, and against 225 upon B is $6 75, the rate per cent, which added to 225 gives $231 75, the answer.

Or, by rule 2d—Set 100 upon B to 103 upon *A*, and against 225 is $231 75 upon A, the answer as before.

2. What is the value of $675 at 5 per cent below par? By rule 2d—Set 100 upon B to 95 upon A, and against 575 upon B is $603 75 upon A, the answer.

*That is, the sum or difference of the rate per cent and 100, according to the nature of the problem.

INSURANCE.

Insurance is a contract by which the insurer undertakes, in consideration of a premium equivalent to the hazard sum, to indemnify, in case of loss, the person insured, against certain perils or some particular event.

The instrument by which the contraot of indemnity is effected is called the Policy; and is signed only by the insurer, who is called the Underwriter. The money paid by the insurer for the insurance, is ealled the Premium.

Examples.

1. What will be the premium for insuring a ship and cargo from Dartmouth to Liverpool, valued at 2,500 dollars at 3 per cent?

Set 1 upon B to 03 upon A, and against $25000 upon B, will be 750 dollars upon A, the answer.

2. What will be the premium for insuring a ship and cargo, valued at 42000 dollars, to sail from Boston to London, at a premium of five per cent?—answer, $21000.

3. What will be the annual premium for the insurance on property against losses from fire, valued at 2300 dollars, at 2 per cent?

Set 1 upon B to 02 upon A, and against $2,500 upon B will will be 50 dollars upon A, the answer.

4. What will be the annual premium for insurance on a house against loss by fire, valued at 2,000 dollars, at 2½ per cent?—answer 50 dollars.

LOSS AND GAIN.

Loss and Gain is where property is sold for less

or more than cost. The profit made in selling is called Gain, and where property is sold for less than cost is called Loss, and is reckoned at so much per cent.

Examples.

1. A merchant purchased a quantity of goods for 250 dollars; how much must he sell the lot for, to gain 25 per cent?

It will be discovered that this does not differ from any of the former examples.

Set 1 upon B to 25 upon A, and against $250 upon B, will be $62,50 upon A, the answer.

2. A merchant purchased a quantity of broadcloths for $3,75 a yard; how much must he sell it for to gain 15 per cent?—answer, $6,25.

Note.—The answer to the two last examples is the profit made on the goods sold, and consequently must be added to the cost to get the true answer.

3. A merchant purchased a quantity of goods for 275 dollars, and sold them for 325 dollars; what per cent did he gain?

Set 275 upon B to 325 upon A, and against 1 upon B, is 0116 or, 01½ upon A, the answer.

To find the interest of any number of dollars for any number of days.

Rule.—Bring the rate per cent upon B to 360, the number of Interest days in a year, upon A and against any number of days upon A, will be the interest of 1 dollar upon B, then set 1 upon B, to the interest of 1 d. for the given time, as found by the first operation, upon A, and against the given

number of dollars upon B will be the interest for the same upon A.

Examples.

1. What is the interest of 5 dollars for 25 days at 6 per cent?

Set 6 upon B to 360, the guage point, upon A, and against 25 upon A is ,0045, four mills and a half, the interest of 1 dollar for 25 days; now set 1 upon B to ,0045 upon A and against 5 upon B, is ,022, two cents and two mills, upon A, the answer.

2. What is the interest of 50 dollars for 25 days?

Set 1 upon B to 360 upon A and against 25 upon A is ,045, four cents and five mills, upon B: now set 1 upon B to ,045 upon A and against 50 upon B is ,205, twenty cents and five mills, upon A, the answer.

3. What is the interest of 500 dollars for 250 days at 6 per cent?—Find the interest of 1 dollar, as before directed, for the given time, and set 1 upon B to it upon A and against the 500 dollars upon B will be the answer upon A.

From these three examples it will be seen that many problems, which in arithmetic require separate solutions, may be solved at one operation upon the Slide Rule, thus the last three examples may be considered as one and the same operation a little varied; for after having set the rule for the first example, it is set for the other two by supposing unity to be removed one place further towards the left.

To find the interest of any number of dollars for any number of months.

Rule.—Set 12 [the number of months in a year] upon B to the rate per cent upon A, and against the given number of months upon B will be the interest of 1 dollar for the same upon A; then set 1 upon B, to the interest of 1 dollar for the given time, upon A, and against the given number of dollars upon B will be the answer in dollars and cents upon A.

Examples.

1. What is the interest of 75 dollars for 3 months?—Set 12 upon B to 6 upon A and against 3 upon B is ,015, one and a half cents, upon A; now set 1 upon B to ,015 upon A and against 75 upon B will be 1,125, one dollar and 12½ cents upon A, the answer.

Remark.—This example can be varied at pleasure, as in former examples.

To find the interest of any number of dollars for any number of weeks.

Rule.—Find the interest of one dollar for the given time, as in the last rule, and multiply the interest thus found, by the given number of dollars for the interest required.

Examples.

1. What is the interest of 25 dollars for 32 weeks?—Set 52, the number of weeks in a year, upon B to 6, [lawful interest of 1 dollar for 52 weeks] upon A, and against 32 upon B is ,037, three cents and seven mills, upon A, the interest

of one dollar for the given time; now set 1 upon B to ,037 upon A, and against 25 upon B is ,925, ninety-two and a half cents, npon A, the answer.

2. What is the interest of 63 dollars for 3 weeks at 6 per cent?—Set 52 upon B to 6 upon A, and against 3 upon B is ,003, three mills, upon A, the interest of 1 dollar for the given time; now set 1 upon B to ,003 upon A, and against 63 dollars, upon B is 19 cents, nearly, upon A, the answer.

3. What will the interest of $200 amount to in 1 week, at 6 per cent?

Set 52 upon B to ,06 upon A and against 1 upon B is ,00115, that is, one mill and fifteen hundreths, npon A, the interest of 1 dollar for one week; now set 1 upon B to ,00115 on A and against 200 upon B is ,23, twenty-three cents upon A, the answer.

4 What is the interest of 9 dollars for 40 weeks at 5 per cent?—Set 52 on B to ,05 on A, and against 40 on B will be ,0387, three cents eight mills, nearly, the interest of 1 dollar for 40 weeks; now set 1 on B to ,0387 on A and against 9 on B is ,348, thirty-four cents eight mills upon A, the answer.

5. What is the interest of 14 dollars for 40 weeks at 5 per cent? Ans. ,54, fifty-four cents.

6. What for 18 dollars? Ans. ,69, sixty nine cents.

7. What for 25 dollars? Ans. ,97, ninety-seven cents.

Remark.—The decimal point placed before the cents in the preceding examples, is used to

show that the figures before which it is placed are hundredths of a dollar; and does not imply that they may not be represented on the instrument as whole numbers, since in interest they are always on a different line from the dollar.

Time, and rate per cent and amount given to find the principal.

RULE.—Set the amount of one dollar for the given rate and time, upon B to 1 (dollar, not 100 cents) on *A*, and against the amount on B, will be the principal on *A*.

Or—As the amount of 1 dollar for the given rate and time, on B is to 1 dollar on *A*, so is the amount on B to the principal on A.

Examples.

1. What sum of money put at interest at 6 per cent., will amount to 50 dollars in one year?

The amount of 1 dollar for the given rate and time is $1,06, 1 dollar and six cents,—therefore set 1,06 on B to 1 on *A*, and against 50 on B is 47,17 dollars on A, the answer.

2. What sum of money put at interest at 8 per cent, will amount to 400 dollars in two years?

Set $1,16 on B to 1 on A, and against 400 on B, is $344,82 upon A, the answer.

3. What principal at 4 per cent., in three years will amount to 60 dollars?—Set $1,12, the amount of 1 dollar for three years, upon B to 1 (dollar) upon *A*, and against 60 upon B is $52,57 upon *A*, the answer.

Note.—When time is not considered the rate per cent is added to $1, and the operation is conducted as before, *i.e.* in the last example.

4. What will be the residue of 650 dollars after a commission of 5 per cent. has been deducted?

Set $1,05 [one dollar and five cents] upon B to 1 upon *A*, and against 650 upon B, is $61,90, [sixty-one dollars and ninety cents] upon A, the answer.

REMARK.—The above axample will illustrate the operations of all cases in which there is no premium on the amount of percentage, that is, what is due to the Factor.

DISCOUNT.

'Discount is an allowance made for any sum of money before it becomes due.'

RULE.—Set the amount of 1 dollar for the given time on B to 1 on A, and against the amount to be discounted on B will be the present worth on A.

Note.—The above rule is to find the *present worth*, and not *discount*, but as discount is dependent upon the *present* worth, that is, the *present worth* must be first ascertained before the discount can be, both are generally presented under one head.

Examples.

1. Suppose a man owes a debt of 400 dollars, to be paid in one year, without interest, and he wishes to pay it now, how much will he have to pay to cancel the debt?—Set $1,06 upon B to 1 (dollar) on *A*, and against $400 upon B, will be $377,36 on *A*, the answer.

Note.—$377,36 is what the debt is worth now, that is, it is the *present worth*: and if it is required to find the discount on the $400 for the above time at 6 per cent., all that is now necessary is to subtract 377,36 from 400, which gives $22,64 for the discount.

Remark.—The foregoing Rule might perhaps be better understood if expressed thus: as the amount of $1 for the given rate and time on B, is to $1 on A, so is the amount to be discounted on B to the present worth on *A*.

2. What is the present worth of 6 dollars, payable two years hence, discounting at the rate of 6 per cent?

Set $1,12, the amount of 1 dollar at the given rate and time, on B to $1 on A and against $6 on B is $5,36 on A, the answer.

3. What is the discount on the above? ,$0,64, Ans.

4. What is the present worth of 10 dollars payable 1 year and 6 months hence, discounting at 5 per cent?—Set 1,075 on B to 1 on A, and against 10 on B, will be $9,29 on *A*, the answer.

5. What is the discount on the above? Ans. $0,71.

6. What is the present worth of $3 payable 4 years hence, discounting at the rate of 2 per cent?

Set $1,08, the amount of 1 dollar for four years at 2 per cent, on B to $1 on A, and against $3 on B will be $2,77 on A, the answer.

7. What is the discount on the above? Ans. $0,33.

8. What is the present worth of 1 dollar, pay-

able 1 year hence, discounting at the rate of 4 per cent ?—Set $1,04 on B to $1 on *A* and against $1 on B, $0,965, ninety-six cents and five mills, on *A*, the answer.

9. What is the discount on the above ? *Ans.* $,0,035,

Remark.—It will be observed that as the slider now stands, it forms a table of *present worths* of any number of dollars and cents, for one year, discounting at the rate of 4 per cent.

Note.—The principle upon which the foregoing Rules are founded, is this: that 1 dollar with its interest, for a certain time bears the same proportion to 1 dollar, : that any number of dollars with its interest, at the same rate per cent and for the same time, bear to its principal.

The time, rate per cent and interest being given, to find the principal.

Rule.—Set the interest of 1 dollar on B to 1 dollar on *A* and against the given gain or interest on B, will be the principal required, on A.

Or—As the interest of 1 dollar on B is to 1 dollar on *A*, so is the given interest on B to its principal on A.

Remark.—The interest of the 1 dollar and the given interest must have the same percentage and time.

Examples.

1. How much money must I put at interest 12 months to have it gain $4, at 3 per cent ?

Set $1,03, the interest of 1 dollar for 12 months, on B to $1 on *A* and against $4 on B is $133,33

[one hundred and thirty-three dollars and thirty-three cents] on A, the answer,

2. What principal must be put at interest, at 6 per cent for 18 months, to gain 8 dollars?

Set 9 cents, the interest of 1 dollar for the given time, on B to 1 dollar on A, and against 8 dollars on B is $88,83 upon A.

The principal, interest and time being given, to find the rate per cent.

Rule.—Set the interest at one per cent on the given principal for the given time, on B to 1 cent on A, and against the given interest on B, will be the rate per cent required, on A.

Or—As the interest cast at 1 per cent on the given principal for the given time on B, is to cent, that is, its rate per cent., on A, so is the given interest on B to its rate per cent., that is, the rate per cent. required, on A.

Examples.

1. At 200 dollars paid for the use of 600 dollars for 1 year, what is that per cent?

Set 600 cents, the interest of 600 dollars for 1 year at 1 per cent, on B to 1 cent, its percentage, on A, and against 200 dollars, the given interest, on B is 33⅓ per cent on A, the answer.

2. At 50 dollars paid for the use of 800 dollars for 1 year. what is that per cent? *Ans.* 6 per cent, nearly.

FELLOWSHIP.

RULE.—Set the whole stock, invested by the company, on B, to each man's share of the stock on A, and against the whole gain or loss on B, will be his share of the gain or loss, on A.

Or—As the whole stock on B, is to each man's share on A, so is the whole gain or loss on B, to his share on A.

Examples.

If two men have a joint stock in trade of 200 dollars, and A owns $150 of it, B $50, and the profit arising from trade amounts to $30; what is each one's share?—Set $200 on B to 1 50 on A, and against 30 on B is 22 50 on A, the answer for A's share: and set 200 on B to 50 on A, and against 30 on B is $7 50 on A, B's share.

2. X, Y and Z have a joint stock in trade to the amount of $2500, of which X owns $1500, Z $1200, and Y $800, and by misfortune lose $900, what is each man's share of the loss? Set 2500 on B to 1500 on A, and against 900 on B is $540 on A, X's share of the loss. Set 2500 on B to 1200 on A, and against 900 on B is $432 on A, Z's share of the loss. Set 2500 on B to 800 on A, and against 900 on B is $72 on A, Y's share of the loss.

3. If the expenses of a certain company amount to $350, and the stock in trade is divided into four shares of $4000, $250, and $500, how

much has the owner of each share to pay? Set 4750, the amount of stock in trade, on B to 4000 on *A*, and against 350 on B is $254 73 on *A*, the answer for the first. Set 4750 on B to 250 on A, and against 350 on B is $18 42 on A, the answer for the second—and set 4750 on B to 500 on *A*, and against 350 on B is $36 84 on A, the third man's part to pay.

Remark.—The foregoing rule by which the above problems are solved, is the same, or nearly the same, as the one given in common arithmetics, and is a very proper one for an arithmetical solutions; but the following is better suited to our present purpose, being as simple and more comprehensive than the former:

Rule Second.—Set the stock invested on B to the whole loss or gain on *A*, and against each man's share on B will be his share of gain or loss on *A*.

Or—as the whole stock on B is to the whole gain or loss on A, so is each man's share of the stock on B to his share of the gain or loss on A.

Examples.

1. Four men own a joint stock in trade of $300, of which C owns $80, D $125, E $50, and F $20; at the dissolution of partnership they find they have gained $100, how much is each one's share of the gain? Set 300 on B to 100, the gain, on *A*, and against 80 on B is $26 66 on A, C's share—against 125 on B is $41 66 on A, D's share—against 50 on B is $16 66 on *A*, E's share—and against 20 on B is $6 66 on *A*, F's share to receive, the answer.

2. A bankrupt owes C $90, D $75, E $200, F $50, G $60, to whom he assigns his property which amounts to $110, how much does each creditor receive? Set 475, the amount of debt owed, on B to 110 on A, and against 90 on B is $20 84 on A, what C receives—against 75 on B is $17 37 on A, what D receives—against 200 on B is $46 32 on A, what E receives—against 50 on B is $9 26 on A, what F receives--and against 60 on B is $13 86 on A, what G receives, the answer.

3. A testator supposing himself worth $3500 free and clear from debt, bequeaths $1500 to his elder daughter and $2000 to his younger, but upon the settlement of his estate his administrator finds it to be worth only $3000, how much does each daughter receive for her legacy? Set 3500 on B to 3000 on A, and against 1500 on B is $1285 42 on A, the elder daughter's legacy—and against 2000 on A is $1714 28 on A, the younger daughter's legacy.

4. Two men draw a prize in a lottery of $500, and are to share it in the proportion as 5 is to 6, how much will each receive? Set 11, the sum of 5 and 6, on B to 500 on A, and against 5 on B is $227 28 on A, the first man's share, and against 6 on B is $272 72 on A, the second man's share.

By the rules of Fellowship school bills and taxes are generally made out or computed, and may be done on this instrument as follows:

Thus, for taxes, say, as the whole amount of

taxable property is to the tax to be raised, so is any one individual's property to his tax.

Example.

In a town worth $125,000 a tax of $12,000 is to be raised, what will be the tax of an individual whose property is valued at $8,500? Set 125000 on B to 12000 on A, and against 8500 on B is $8 16 on A, the answer.

Note.—As the slider now stands the lines A and B form a table of property and the tax to be raised on it; for against the value of any individual's property on B will be his tax at that rate on A.

For school bills, say, as the whole number of days of attendance by all the members of a school is to the amount of money to be raised, so is the number of days occupied by any one member to his share to pay.

Example.

Suppose the amount of attendance in a certain school for three months was 950 days, and the amouut of money to be raised was $40, what was the bill of a member who had attended 37 days? Set 950 on B to 40 on A, and against 27 on B will be $1 57 on A, the unswer.

Now, against the days of attendance of any member on B will be the amount of his bill on A.

REDUCTION OF CURRENCIES.

Reduction of currencies is a method by which the currency of one Kingdom or State may be reduced to that of another, as the reduction of pounds sterling to federal money.

To reduce the currency of one State to that of another.

RULE.—Set the number of shillings that make a dollar in one State on B to the number of shillings that make a dollar in another State on A, and against any number of shillings of the former State on B will be their equivalent in the denomination of the latter State on A.

Examples.

1. How many shillings of New England currency is equivalent to 19 shillings of New York currency? Set 8 shillings of New York currency on B to 6 shillings of New England currency on A, and against 19 shillings of New York currency on B is 14 shillings and 3 pence on A, the answer.

2. How many shillings of New York currency is equivalent to 14 shillings of New Jersey currency? Set 7s 6d on B to 8s on A, and against 14s on B is 13s 3d on A, the answer.

Remark.—Six pence is equal to five-tenths; that is, it is equal to five long marks between the primes.

The following table will exhibit the several

currencies of the different States of the Union, or the number of shillings in a dollar in each of the different States mentioned:

One dollar is reckoned in

New England States, Virginia, Kentucky, Tennessee,	6s, called New England currency.
New York, Ohio, North Carolina,	8s, called N. Y. currency.
New Jersey, Pennsylvania, Delaware, Maryland,	7s 6d, called Penn. currency.
South Carolina, Georgia,	4s 8d, or Georgia currency.

3. How many shillings of Georgia currency is equal to 20s Penn. currency? Set 7s 6d on B to 4s 8d on *A*, and against 20s on B is 12s 5d on A, the answer.

Remark.—Eight pence is about sixty-six-hundredths, or six and a half tenths of a shilling.

4. How many shillings New York currency is equal to 9s Georgia currency? Set 4s 8d on B to 8s on A, and against 9s on B is 15s 5d on A, the answer.

As the slider now stands the line B is a table of Georgia currency with their equivalents in New England currency on A.

One dollar is reckoned in England 4s 6d, called English money. In Canada and Nova Scotia, 5s, called Canada currency.

To reduce English or Sterling money to Canada Currency.

Examples.

1. How many shillings English or sterling, are equal to 12s Canada currency? Set 5s, of Canada currency on B to 4s 6d, sterling, on A, and against 12s, of Canada currency, on B is 10s 9½d on A, the answer.

2. How many shillings sterling are equivalent to 20s of Canada currency? Set the slider as in the last example, and against 20 on B is 18s on A, the answer.

As the slider now stands the line B is a line of Canada currency, and the line A is a line of English or sterling money, and against any number of shillings of Canada currency on B is their equivalent in sterling money no A, and *vice versa.*

Questions on Currency.

1. What is the number of dollars that has 2s more of Canada currency in them than of sterling? Ans. $4.

2. What number has 1s more of Canada than of sterling currency in them? $2 answer.

3. What is the number of dollars that has 2s 6d less of sterling than of Canada currency in them? $5 answer.

The following table of guage points will serve to reduce pounds to dollars, and *vice versa.*

One dollar	N. England	currency is	,3	of a pound.
do	New York	do	,4	do
do	Pennsylvania	do.	,375	do
do	Georgia	do	,233	do

One dollar England currency is ,225 of a pound.
do Canada do 4 units do*

To reduce Pounds to Dollars, and vice versa.

Rule.—Set 1 on B to the guage point on A, and against any number of dollars on B will be their equivalent in pounds on A.

Or—Set the guage point on B to 1 on A, and against any number of pounds on B will be their equivalent in dollars on A.

Examples.

1. How many dollars are there in £1 N. E. currency? Set ,3 on B to 1 on A, and against £1 on B is $3 33 on A, the answer.

2. How many dollars are there in £20 N. E. currency? Set ,3 on B as before, to 1 on A, and against 20 on B is 66 2-3 dollars on A, the answer.

How many dollars are there in £1 New York currency? Set ,4 (four tenths) on *B* to 1 on *A*, and against £1 on B is $2 50 on *A*, the answer.

Remark.—As the slider now stands, the line B is a column of pounds and the line A a column of dollars; for against any number of pounds on B is their equivalent in dollars on A, New York currency.

Examples.

How many dollars are there in £2? ans. $5. How many in £3? ans. $7 50. How many in £4? ans. $10. How many in £5? ans. $12 50. How many in £6? ans. $15. How many in £7? ans.

* Instead of setting this guage point on B to 1 on A, set B to it on A, and proceed as directed by the rule.

$17 50. How many in £8? ans. $20. How many in £9? ans. $22 50. How many in £10? ans. $25.—How many pounds are there in $4? ans. £1,6 (tenths.) In 5? ans. £2. In 6? ans. £2,4. In 7? ans. £2,8. In 8? ans. £3,2. In 9? ans. £3,6. In 10? ans. £4. In 12? ans. £4,8. In 13? ans. £5,2. In 14? ans. £5,6. In 15? ans. £6. In 16? ans. £6,4. In 17? ans. £6,8. In 18? ans. £7,2. In 19? ans. £7,6. In 20? ans. £8. In 25? ans. 10. It may be continued in this manner as far as it is desired.

4. How many dollars are there in £1 Penn. currency? Set ,375 (three hundred and seventy-five-thousandths) on B to 1 on A, and against 1 on B are $2 66 on A, the answer. How many dollars are there in £2? ans. $5 32. How many in 3? ans. $7 98. How many in 4? ans. $10 64. How many in 5? ans. $13 30. How many in 6? ans. $15 96. How many in 7? ans. $18 62. How many in 8? ans. $21 28. How many in 9? ans. $23 94. How many in 10? ans. $26 66. How many in 20? ans. $53 32. How many in 18? ans. $47 88. How many in 12? ans 31 92. How many pounds are there in $3 Penn. currency? ans £1,13. How many in 6? ans £2,25. How many in 4? ans £1,492, or £1,5 nearly. How many in 5? ans £1,86. How many in 7? ans £2,61. How many in 8? ans £3 nearly, that is, £2,984. How many in 9? ans £3,36. How many in 10? ans £3,73. How many in 16? ans £5,97. How many in 24? ans £8,96. How many in 25? ans £9,3.

5. How many dollars are there in one pound Georgia currency? Set ,233, the guage point, on

B to 1 on A, and against 1 on B is $4 28 on A, the answer.

Let the following represent the two lines:

	B		A
Now against	£2	are	$ 8 56
"	3	"	12 84
"	4	"	17 12
"	5	"	21 40
"	6	"	25 68
"	7	"	29 96
"	8	"	34 24
"	9	"	38 52
"	10	"	42 80

and so on to any extent desired.

Let the slide remain as in the last example, and let the following represent the two lines:

	A		B
Then against	$ 5	are	£1,16
"	10	"	2,32
"	15	"	3,48
"	20	"	4.64
"	25	"	5,8
"	30	"	6,96
"	1	"	0,233
"	2	"	0,466
"	3	"	0,7
"	4	"	0,932
"	7	"	1,62
"	9	"	2,09
"	12	"	2,79
"	14	"	3,26
"	16	"	3,73
"	18	"	4,18
"	19	"	4,43

To reduce the currency of one country to the currency of the same name in another:

For which the following table of guage points will serve. To reduce—

English currency to New England,	1,33
English to Canada currency,	1,11
English to New York currency,	1,78
English to Pennsylvania currency,	1,36
English to Georgia currency,	1,01

RULE.—Set 1 on B to the guage point on A, and against any number of pounds to be reduced on B will be their equivalent in the proposed currency in pounds and tenths of a pound on A.

Examples.

1. Reduce 3 pounds English to its equivalent in pounds of New England currency. Set 1 on B to 1,33 on A, and against 3 on B is 4 pounds on A, the answer.

2. How many pounds New England currency are equivalent to £4 sterling? Let the slider remain as in the last example, and against 4 on B is 5,3 on A, answer.

3. How many pounds of New York currency are equivalent to 2 pounds sterling? Set 1 on B to 1,78 on A, and against 2 on B is £3,56 on A, the answer.

4. How many pounds of New York currency are equivalent to 4 pounds sterling? Let the slider remain as before, and against 4 on B is £7,1 on A, the answer.

5. How many pounds of Canada currency are equivalent to 7 pounds sterling? Set 1 on B to

1,11 on A, and against 7 on B is L7,8 on A, the answer.

6. How many pounds of Pennsylvania currency are equivalent to 3 pound sterling? *Ans.* L4,1.

7. How many pounds of Georgia currency are equivalent to 5 pounds sterling? *Ans.* L5,8.

SQUARE AND CUBE ROOT.

To raise a number to its second power.

This is performed on the lines C and D.

Rule.—Set 1 on C to one on D, then against any number on D will be its square on C.

Note.—As 10 is the only division on D that can be used for unity or one, it must in this instance be taken for it.

Examples.

1. What is the second power or square of 8? Set 1 on C to 1, or 10 used as 1, on D, and against 8 on D is 64 on C, the answer.

2. What is the square of 12? Let the slider remain as in the last example, and the lines C and D form two columns, one of numbers with their squares on the other: consequently, against 12 on D is 144 on C, the answer. What is the

square of 13? ans 169. What of 14? ans 196. What of 20? ans 400. What of 25? ans 625. What of 120? ans 14400. What of 130? ans 16900. What of 250? ans 62500. What is the square of ,3? ans ,9. What is the square of ,4? ans ,16, sixteen-hundredths. What of ,9? ans ,81. What of ,12, twelve tenths, or 1,2, one and two-tenths? ans 144 hundredths, or 1,44, one unit and forty-four-hundredths.

In this manner the second power of most any number may be obtained with a sufficient degree of accuracy for all common purposes. To obtain the last figure of the square with accuracy, all that is necessary is to multiply the last figure of number to be squared in the head, which will give it.

To find the square root of any number.

RULE.—Set 1 on C to 1, or 10 used as 1, on D, and against and number on C will be its square root on D.

Examples.

1. What is the square root of 625? Set 1 on C to 1 or 10 on D, and against 625 on C is 25 on D, the answer.

2. What is the square root of 1296? Let the slider remain as in the last example, and against 1296 on C is 36 on D, the answer.

3. What is the square root of 49? ans 7. Of 490? ans 22,13 nearly. Of 4900? ans 70. Of 49000? ans 221,3.

Remark.—Square root, as performed on this rule, may be stated and solved in the form of a

proportion, by the following statement: As 1 on D is to its square or second power (1) on C, so is any number on D to its square on C—or, as 1 on C is to its square root on D, so is any number on C to its square root on D. Or it may be stated as any number on D is to its square on C, so is any other number on D to its square on C, and *vice versa.*

Examples.

1. What is the square of 8? As 1 on D is to 1 on C, so is 8 on D to 64 on C, the answer.

2. What is the square root of 64? As 1 on C is to 1 on D, so is 64 on C to 8 on D; or as 4 on D is to 16 on C, so is 8 on D to 64 on C, and *vice versa.*

To find the Cube of any number, that is, to raise a number to its third power.

RULE.—Set the number you want the cube of on C to 1 (or 10 used as 1) on D, then against the same number on D will be its cube on C.

Examples.

1. What is the cube of 3? Set 3 on C to 1 on D, and against 3 on D is 27 on C, the answer

2. What is the cube of 9? Set 9 on C to 1 on D, and against 9 on D is 729 on C, the answer.

3. What is the cube of 90? Set 90 on C to 1 on D, and against 90 on D is 72900 on C, the answer.

To extract the cube root by one operation.

RULE.—Invert the slider and set the given number on B to 1 (or 10 used as 1) on D, and seek for

a number on D that coincides with a like number on B, which will be the cube root sought.

Examples.

1. What is the cube root of 27? Set 27 on B to 1 or 10 on D, then against 3 on D is 3 on B, the number sought.

2. What is the cube root of 64? Set 64 on B to 1 on D, then 4 on D coincides with 4 on B, which gives the required number.

3. What is the cube root of 81? Set 81 on B to 1 on D, and then 4,35 nearly coincides with 4,35, which is the cube root required.

4. What is the cube root of 85? Set 85 on B to 1 on D, and then 4,4 on D coincides with 4,4 on B, which is the cube root sought.

5. What is the cube root of 90? Set 90 on B to 1 on D, then 4,48 on D coincides with 4,48 on B, which gives the answer.

Remark.—Great care should be observed in setting the given number on B to 1 on D, for on this depends, in a great measure, the accuracy of the result.

MECHANICS.

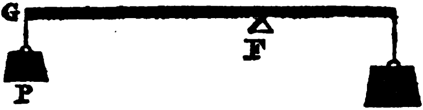
Many solutions of problems in "Mechanics" may be expeditiously solved on this Instrument, with a sufficient degree of accuracy for all practical purposes.

THE LEVER.

As there are various modifications of the Lever it may be proper to mention them separately, and point out the peculiarity of each.

OF A LEVER OF THE FIRST ORDER.

A Lever of the first order is one that has the fulcrum or prop between the power and the weight, as shown in the figure below, where F is the fulcrum, W the weight, and P the power:



To find the weight, when the power and length of lever are given together with the situation of the fulcrum or prop:

RULE.—As the distance between the weight and fulcrum in feet, inches, &c. is to the distance between the fulcrum and G, so is the power in pounds, ounces, &c. to the weight in the same de-

nomination: hence, set the distance between the W, or the end of the bar on which it hangs, and F, on B, to the distance between the F and G on A, and against the power on B is the weight on A.

Examples.

1. Suppose there is a bar or lever 7 feet long, which rests on a fulcrum or prop 3 feet from one end, how much weight, attached to the shortest part, may be raised by a power of 10 pounds applied at the end of the longest? Set 3 on B to 4 on A, and against 10 on B is 13,3 pounds on A, the answer.

2. What weight, attached to the end of a lever 14 feet long can be raised by a power of 15 pounds applied to the other, when the prop is placed 3 feet from the weight? Set 3 on B to 11 on A, and against 15 on B is 55 pounds on A, the ans. What weight, applied as before to the above lever, can be raised when the prop is 2 feet from the weight? Set 2 on B to 12 on A, and against 15 on B is 90 pounds on A, the answer. What will 20 pounds raise when the prop is 5 feet from the weight, and the lever situated as above? Set 5 on B to 9 on A, and against 20 on B is 36 pounds on A, the answer. What will be raised when the prop is 8 feet from the weight? Set 8 on B to 6 on A, and against 20 on B is 15 pounds on A, the answer. What weight will be raised when the prop is 1 foot from the weight? Set 1 on B to 13 on A, and against 20 on B is 260 pounds on A, the answer. What weight will be raised when the prop is ½ foot from the weight? Ans. 540 pounds.

The weight and power given together with the length of beam, to find the situation of the fulcrum.

RULE.—As the sum of the weight and power is to the whole length of beam, so is the power to the distance between the fulcrum and weight: therefore, set the sum of the weight and power on B to the length of the bar on A, then against the power on B will be the distance between the fulcrum and weight on A.

Example.

1. Where is the situation of the fulcrum when the bar is 14 feet long, and the weight and power are 36 and 20 pounds respectively? Set 56 on B to 14 on A, then against 20 on B is 5 feet, the distance between the prop and weight, on A, the answer.

2. Where is the prop situated when the lever is 14 feet long, and the weight and power are 55 and 15 pounds respectively? Set 70 on B to 14 on A, and against 15 on B is 3 feet, the distance between the prop and weight on A, the answer.

3. Where is the prop situated on a lever 14 feet long, when the weight and power are 15 and 20 pounds respectively? Set 35 on B to 14 on A, and against 15 on B is 6 feet on A, the answer.

The length of beam, weight, and situation of the fulcrum given, to find the power.

RULE.—As the distance between the power and fulcrum is to the distance between the fulcrum and weight, so is the weight to the power: therefore, set the distance between the power and prop or fulcrum on B to the distance between the prop

and weight on A, and against the weight on B will be the power on A.

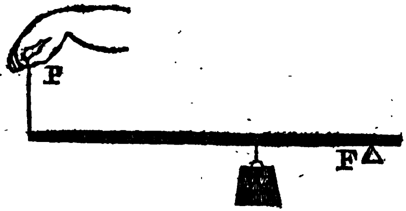
Example.

1. What power is necessary to raise a weight of 36 pounds attached to the end of a lever 14 feet long, when the prop is 5 feet from the weight? Set 9 on B to 5 on A, and against 36 on B is 20 pounds on A, the answer.

2. What power, applied to the end of a lever 7 feet long, is necessary to raise a weight of 13,3 pounds attached to the other end, when the prop is 3 feet from the weight? Ans. 10 lbs.

OF THE SECOND ORDER OF LEVERS.

In levers of the second order the weight is between the fulcrum and power. In this case the power and weight are on the same side of the fulcrum, as is seen in the figure below:



The length of lever, power, and situation of fulcrum given, to find the weight.

RULE.—As the distance between the weight and fulcrum is to the distance between the weight

and power, so is the power to the weight: therefore, set the distance between the fulcrum and weight on B to the distance between the weight and power on A, then against the power on B is the weight on A.

Examples.

1. What weight, attached to a bar 12 feet long 5 feet from the fulcrum, can be raised by a power of 25 lbs? Set 5 on B to 7 on *A*, and against 25 on B is 35 lbs on A, the answer.

2. What weight, attached to a bar of the above dimensions 2 feet from the prop, can be raised by a power of 25 lbs? Set 2 on B to 10 on A, and against 25 on B is 125 lbs on A, the answer.

The length of lever, weight, and situation of fulcrum given, to find the power.

RULE.—As the distance between the power and weight is to the distance between the weight and fulcrum, so is the weight to the power: therefore, set the distance between the power and weight on B to the distance between the power and prop on A, then against the weight on B will be the power on *A*.

Examples.

1. What power, applied to the end of a lever 12 feet long, is necessary to raise a weight of 30 lbs suspended 3 feet from the end of the fulcrum? Set 9 on B to 3 on *A*, and against 30 on B is 10 on A, the answer.

Remark.—The applications of this kind of lever to various uses are very common. Two persons carrying a load suspended on a bar between them

is a familiar example; doors and gates are constructed on this principle; the shafts of a carriage are a lever of this kind, in which the axletree is the fulcrum, the seat the weight, and the strength necessary to set it upright applied at the end of the shafts is the power. There are various other applications of this kind of lever that might be mentioned, but the above will serve sufficiently for illustrations.

The weight, power, and length of lever given, to find the fulcrum.

As the sum of the weight and power is to the whole length of the lever, so is the power to the distance of the fulcrum from the weight: consequently, set the sum of weight and power on B to the length of lever on A, then against the power on B will be the distance of the fulcrum from the weight on A.

Examples.

1. Where is the fulcrum situated in a lever 15 feet long, when the weight and power are 90 and 10 lbs respectively? Set 100 on B to 15 on A, and against 10 on B is 1,5 feet (that is, 1 foot and 6 inches) on A, the answer.

2. Where is the fulcrum situated in a lever of the above dimensions when the power and weight are 20 and 50 lbs respectively? Set 70 on B to 15 on *A*, and against 20 on B is 4,2 feet nearly on *A*, the answer.

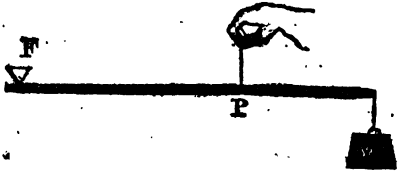
3. Where is the fulcrum situated in a lever of the above dimensions, when the power and weight are 4 and 80 lbs respectively? Set 84 on B to 15

on A, and against 4 on B is ,7 (seven-tenths of a foot, or about 8½ inches) on A, the answer.

Remark.—From the preceding examples it will be observed that the nearer the weight is to the fulcrum in comparison with the whole length of the lever, so much the less power is required to raise it. This remark is applicable to all kinds of levers whatever.

OF THE LEVER OF THE THIRD ORDER.

In levers of the third order the power is applied between the weight and fulcrum, as seen in the following figure, in which F W P denote the fulcrum, weight, and power, respectively:



To find the weight, when the length of lever, power and situation of fulcrum are given.

RULE.—As the distance of the weight from the fulcrum is to the distance of the power from the same, so is the power to the weight: consequently, set the distance of the weight from the fulcrum on B to the distance between the power and fulcrum on A, then against the power on B will be the weight on A.

Note.—In this kind of lever the length is reckoned from the weight to the fulcrum.

Examples.

1. What weight, attached to a lever of the third kind, 25 feet long, can be raised by a power of 40 lbs applied 10 feet from the fulcrum? Set 25 on B to 10 on A, and against 40 on B is 16 lbs on A, the answer.

2. What weight, attached to a lever of the third kind, 12 feet long, can be balanced by a power of 16 lbs, applied 3 feet from the fulcrum? Set 12 on B to 3 on A, and against 16 on B is 4 lbs on *A*, the ans.

3. What weight, attached to the end of a lever of the above dimensions, can be raised by a power of 16 lbs applied 6 feet from the fulcrum? Set 12 on B to 6 on A, and against 16 on B is 8 lbs on A, the answer.

4. When the lever and power are as above, what weight can be raised if the power be applied 8 feet from the prop? Ans, 10 2-3 lbs.

Remark.—From the foregoing examples it will be seen that the power is always greater than the weight, and exceeds it in the proportion that the distance of the weight from the fulcrum exceeds the distance of the power from the same, consequently the weight can never equal the power.

The length of bar, weight, and situation of fulcrum given, to find the power.

RULE.—As the distance of the power from the fulcrum is to the distance of the weight from the same, so is the weight to the power: therefore,

set the distance of the power from the fulcrum on B to the distance of the weight from the same, (or, in other words, to the length of the bar) on A, and against the weight on B will be the power necessary to raise the weight on A.

Examples.

1. What power is necessary to raise a weight of 20 lbs attached to a lever of the third kind, 15 feet long, to be applied 5 feet from the fulcrum? Set 5 on B to 15 on A, and against 20 on B is 60 lbs, or a power equal to 60 lbs, on A, the ans.

2. What power is necessary to raise a weight of 25 lbs attached to a bar 10 feet long, when the power is applied 6 feet from the fulcrum? Set 6 on B to 10 on A, and against 25 on B is 41 2-3 lbs on A, the answer.

3. When the lever and weight are situated as above, what power, applied 4 feet from the fulcrum, is necessary to raise the weight? *Ans.* 62,5, or 62½ lbs.

The weight, power, and length of lever given to find the situation of the fulcrum.

Rule.—As the power is to the weight, so is the length of the lever (that is, the distance of the weight from the fulcrum) to the distance of the power from the fulcrum: therefore, set the power on B to the weight on A, and against the length of lever on B will be the distance of the power from the fulcrum on A.

1. Where is the fulcrum situated in a lever of the third kind 14 feet long, when the weight and power are 6 and 10 lbs. respectively? Set 10 on B to 6 on A, and against 14 on B is 8,4 feet on A.

2. Where is the fulcrum situated in a lever 10 feet long when the weight and power are as above? Set 10 on B to 6 on *A*, and against 10 on B is 6 feet on A.

3. How far is the power applied from the fulcrum in a lever 12 feet long, when the power and weight is 30 and 9 lbs respectively? Set 30 on B to 9 on A, and against 12 on B is 3,6—*i.e.* 3 feet 6 tenths—on A, the answer.

The power, weight, and situation of the fulcrum given to find the length of lever.

Rule.—*As* the weight is to the power, so is the distance of the power from the fulcrum to the length of the lever: therefore set the weight on B to the power on A, and against the distance of the power from the fulcrum on B is the length of lever on A.

Examples.

1. If it be required to raise a weight of 60 lbs by a power of 80 applied 2 feet from the fulcrum, what is the length of the lever or bar by which it can be performed? Set 60 on B to 80 on A, and against 2 on B is 2 2-3 feet on A, the answer.

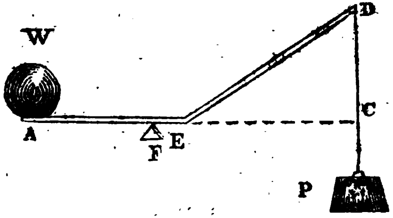
2. What length of bar is necessary to raise a weight of 20 lbs, by a power of 28 lbs applied 5 feet from the fulcrum? Set 20 on B to 28 on A, and against 5 on B is 6 feet on A, the answer.

3. What length of bar is necessary to raise a weight of 50 lbs by a power of 75 lbs applied 3 feet from the fulcrum? Set 50 on B to 75 on *A*, and against 3 on B is 4,5 feet (that is, 4 feet 6 inches) on A, the answer.

4. What length of bar is necessary to raise a

weight of 13 lbs by a power of 20 applied 6 feet from the fulcrum? *Ans.* 9,23 feet.

Remark.—There is another form of lever, considered by some a fourth kind, but in fact is only a lever of the first order, as will be seen by the following figure, in which W is the weight, F the fulcrum, P the power, and A E D the lever or bar:



To compute the power or ascertain the advantage of this lever, correctly, it is necessary to ascertain the distance from E to C in a direct line with A C E, and use the distance A E C instead of A E D in the operation. Examples in this kind of lever are unnecessary.

Remark.—By examining the preceding rules for finding the weight when the power, length of lever, and situation of fulcrum are given, it will be seen that they all amount to the same, and might be expressed in one general rule, for they are all founded on one general principle, which is; the power multiplied by its distance from the fulcrum equals the weight multiplied by its distance from the same. Upon this general princi-

ple, which is applicable to all kinds of levers, is founded all the rules respecting them. The rule for finding the weight that may be raised by a given power, &c. in the preceding pages, is stated for the sake of simplicity and perspicuity in the Rule of Three Direct, but is generally given in the Rule of Three Inverse, as the following, which will serve for a general rule for all the different kinds of levers, and is the only one that need be observed for finding the weight to be raised by any given power.

GENERAL RULE.—*Invert the slider, set the distance of the power from the fulcrum on C to the power on A, and against the distance of the weight from the fulcrum on C will be the weight on A*—i. e. *as the distance of the power from the fulcrum on C is to the power on A, so is the distance of the weight from the fulcrum on C to the weight on A. and vice versa.*

THE PULLEY.

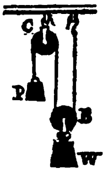
Remark.—As there is no advantage gained in power by a *fixed pulley*, there will be nothing said here respecting it.

OF THE MOVEABLE PULLEY.

To find the weight that may be raised by a set of pulleys, when their number and the power are given.

In the moveable pulley the weight is double the power, because the power moves over double the

space that the weight does in the same time, and what is gained in power is lost in time. The following figure represents a pulley of this kind, in which P is the power, W the weight, B the moveable and C the fixed pulleys. As there are two folds of the cord about the moveable pulley B, the weight is distributed into two parts, consequently it only requires a power equal to half the weight to keep it in equilibrium.



RULE.—Set 1 on B to 2 on *A*, and against the power on B will be the weight on *A*.

Examples.

1. What weight attached to a moveable pulley can be raised by a power of 20lbs? Set 1 on B to 2 on A, and against 20 on B is 40 on A, the answer.

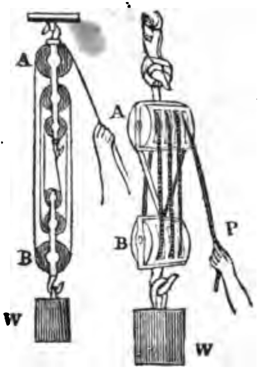
2. What weight, attached to a moveable pulley, can be raised by 75 lbs applied to the end of the cord as a power? Set 1 on B to 2 on *A*, and against 75 on B is 150 lbs on A, the ans.

Owing to friction, &c. all the power is not realized that is estimated in theory, for by these causes nearly one-third of the power is lost.

OF THE COMPOUND PULLEY.

"Compound pulleys are a combination of many pulleys, in which the weight is distributed over a greater number of parts of the rope, each part consequently sustains a smaller portion of the weight."

The following figures represent compound pulleys, where P denotes the power, W the weight, B the moveable and A the fixed blocks which contains the pulleys.



To find the power of a compound pulley when the weight and number of pulleys are given.

RULE.--As the whole number of pulleys in both blocks is to one, so is the weight to the power.

Example.

1. What power is necessary to raise a weight of 400 lbs by a pair of blocks containing 16 pulleys, that is, 8 in the lower and 8 in the upper block? Set 16 on B to 1 on A, and against 400

on B is 25 lbs, or a power equal to 25 lbs, on A, the answer.

2. What power is necessary to raise a weight of 800 lbs hung at a pair of blocks containing 8 pulleys, 4 loose and 4 fixed? Set 8 on B to 1 (pulley) on *A*, and against 800 on B is 100 lbs power on A, the answer.

Instead of the above rule the following may be used: As the whole number of pulleys or ropes in both blocks is to the weight, so is one pulley or rope to the power necessary to hold the weight in equipoise.

To find what weight may be raised with a compound pulley by a given power.

RULE.—As one pulley or rope is to the given power, so is the whole number of pulleys or ropes in both blocks to the required weight: therefore, set 1 (pulley) on B to the whole number of pulleys on A, and against the given power on B will be the required weight on A.

Example.

1. What weight can be raised with a pair of blocks containing 7 pulleys, 3 in the lower block and 4 in the upper, by a power of 15 lbs? Set 1 on B to 15 on A, and against 7 on B is 105 lbs on A, the answer.

2. What weight attached to a pair of blocks containing 10 pulleys, 5 in each block, can be raised by a power of 40 lbs? Set 1 on B to 40 on *A*, and against 10 on B is 400 on A, the answer.

To find the number of pulleys when the power and weight are given.

RULE.—*As* the power is to one pulley, so is the weight to the whole number of pulleys in both blocks.

Examples.

1. What number of pulleys are necessary to keep a weight of 24 lbs attached to them in equilibrium with a power of 8? Set 8 on B to 1 (pulley) on A, and against 24 on B are 3 pulleys, 2 in the upper block and 1 in the lower, on A.

This may be verified by reversing the process, thus: Set 1 on B to 8 on *A*, and against 3 on *B* is 24 on *A*, for the weight.

2. How many pulleys are necessary to keep a weight of 200 lbs in equilibrium with a power of 10 lbs? Set 1 on B to 10 on A, and against 200 on B are 20 pulleys (10 in the upper block and 10 in the lower) on A, the answer.

This may be proved by reversing the process as in the former example, thus: set 1 on B to 10 on A, and against 20 on B is 200 on A, the ans.

3. How many pulleys are necessary to keep a weight of 600 lbs in eqnilibrium with a power of 200? Set 200 on B to 1 on A, and against 600 on B are 3 pulleys, 2 in the upper and 1 in the lower block, on A.

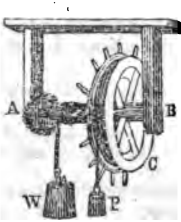
This may also be verified as in the last examples.

Remark.—From the foregoing examples we may draw the following conclusion, viz: that the number of pulleys necessary to keep a given

weight and power in equilibrium, depend upon the *relative* difference between the given weight and power, thus: in the second and third of preceding examples the pulleys are alike, and the actual difference between the power and weight is considerable, but the relative difference is the same.

THE WHEEL AND AXLE.

OF THE SINGLE WHEEL AND AXLE.



The single wheel and axle consists of a single wheel attached to a shaft or axle, as seen in the annexed figure, where A B is the axle, C the wheel, and P W are the power and weight attached respectively to the wheel and axle, by means of cords or ropes.

To find the weight when the power, diameter of the wheel, and diameter of the axle are given.

Rule.—Set the diameter of the axle on B to the diameter of the wheel on A, and against the power on *B* will be the weight on *A*.

Examples.

1. What weight, attached to an axle that is 1 foot in diameter, can be raised bo a power of 16 lbs applied to the circumference of a wheel 8 feet

in diameter? Set 1 foot on B to 8 on A, and against 16 on B are 128 lbs on A, the answer.

2. What weight can be raised by the above described wheel and axle, when the power applied is 50 lbs? Ans 400 lbs.

The reason of the foregoing rule will be readily understood when we consider that the wheel and axle is nothing more than an application of the lever of the first order.

3. What weight, attached to an axle whose diameter is 6 inches, can be raised by a power of 20 lbs applied to the circumference of a wheel whose circumference is 6 feet? Set 6 inches (*i. e.* five-tenths) on *B* to 6 feet on *A*, and against 20 lbs on B is 240 lbs on A, the answer.

To find the power when the weight, and diameters of the wheel and axle are given.

Rule.—Set the diameter of the wheel on B to the diameter of the axle on *A*, and against the weight on B will be the power on A.

Examples.

1. What power, applied at the circumference of a wheel 4 feet in diameter, is necessary to raise a weight of 600 lbs, attached to an axle 1 foot in diameter? Set 4 on B to 1 on A, and against 600 on B is 150 lbs on A, the answer.

2. What power, applied as above, is necessary to raise a weight of 900 lbs, attached to a shaft of 1 foot? Set 4 on B to 1 on *A*, and against 900 on B is 225 lbs on *A*, the answer.

Remark.—There are various modifications of the wheel and axle which are applied to various

purposes, especially to the raising of heavy weights, as in wells, mining, &c.

The weight, power, and diameter of the axle given, to find the diameter of the wheel.

RULE.—Set the power on B to the weight on A, and against the diameter of the axle on B will be the diameter of the wheel on *A*.

Example.

1. What is the diameter of the wheel when the power and weight are 50 and 200 lbs respectively, and the didmeter of the axle is 9 inches? Set 50 on B to 200 on A, and against 9 inches, equal to ,75 [seventy-five hundredths of a foot] on B is 3 feet on A, the answer.

The power, weight and wheel given, to find the axle.

RULE.—Set the weight on B to the power on A, and against the diameter of the wheel on B will be the diameter of the axle on A.

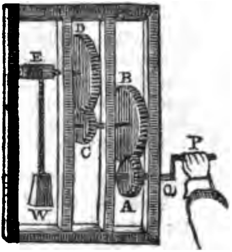
Examples.

1. What is the diameter of the axle when the power and weight are 60 and 800 lbs, respectively, and the diameter of the wheel is 7 feet? Set 800 on B to 60 on *A*, and against 7 on B is ,5 [five-tenths, or 6 inches nearly] on A, the answer.

2. When the wheel is situated as above, what will be the diameter of the shaft if the power and weight are 20 and 1000 lbs? Ans 14 feet.

OF THE COMPOUND WHEEL AND AXLE

The compound wheel and axle consists of cog-wheels connected with the axle, by means of which power to most any extent may be acquired. They work together like a combination of clock-work, as will be seen by the annexed figure, where P Q is considered the semi-diameter of one of the larger wheels, and B D two others, moved by the small ones A C, E the axle, and W the weight.



To find the weight when the power and diameter of all the wheels are given.

RULE.—As the product of the diameters of all the smaller wheels is to the product of all the larger ones, so is the power to the weight.*

Examples.

1. What weight can be raised by a compound pulley and axle, when the diameters of the larger wheels (two in number, including the one formed by the winch) are 2 feet each, and the diameters

* The axle is considered as one of the smaller wheels.

of smaller ones, three in number, including the diameter of the axle round which the rope to which the weight is attached, is coiled, are 1 foot each, and the power applied is 30 lbs? Set 4, the product of the diameters of the larger wheels, on B to 1, the product of the smaller wheels, on A, and against 30 on B is 120 lbs on A, the answer.

2. What weight can be raised by a compound pulley, with a power of 400 lbs, when the product of the smaller wheels is 9, and that of the larger 25? Set 9 on B to 25 on A, and against 400 on B is 1111 lbs nearly, on A, the answer.

To find the power necessary to raise a given weight when the diameter of the wheels are known.

RULE.—As the product of the diameters of the larger wheels or drivers is to the product of the diameters of the smaller ones or drivers, so is the weight to the power.

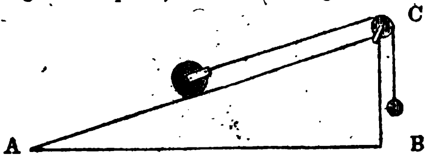
Example.

1. What power is necessary to raise a weight of 600 lbs, when the product of the diameters of the larger wheels are 8 and of the smaller 2? Set 8 on B to 2 on A, and against 600 on B is 150 lbs on A, the answer.

THE INCLINED PLANE.

The Inclined Plane is the most simple of the mechanical powers, consisting of a plane surface inclined to the plane of the horizon, as seen in the following figure, where A B represents a plane

parallel to the plane of the horizon, and A C a plane surface inclined to it. B C is called the height of the plane, and A C the length:



To find the power when the weight and dimensions (i. e. the length and height) are given.

RULE.—As the length A C, is to the height B C, so is the weight to the power.

Example.

What power is necessary to raise a weight of 200 lbs on an inclined plane, whose length and height are 8 and 3 feet respectively? Set 8 on B to 3 on *A*, and against 200 on B is 75 lbs on *A*, the answer.

To find the weight when the power and dimensions of the plane are given.

RULE.—As the height is to the length, so is the power to the weight.

Example.

What weight can be raised by a power of 100 lbs, when the height and length of the plane are 5 and 9 feet respectively? Set 5 on B to 9 on *A*, and against 100 on B is 180 lbs on A, the ans.

To find the height when the power weight, and length of plane are given.

RULE.—As the weight is to the power, so is the length to the height.

Example.

What is the height of an inclined plane when the length is 7 feet and the weight and power to be kept in equilibrium are 200 and 80 lbs respectively? Set 200 on B to 80 on A, and against 7 on B is 2,8 feet on A, the answer.

To find the length when the power, weight, and height are given.

RULE.—As the power is to the weight, so is the height to the length.

Example.

What is the length of an inclined plane necessary to keep in equilibrium a weight and power of 300 and 70 lbs respectively, when the height is 9 feet? Set 70 on B to 300 on A, and against 9 on B is 38½ feet, nearly, on *A*, the answer.

THE SCREW.

The screw acts upon the principle of the inclined plane, the thread being the inclined surface, and the distance between the threads the height. To the screw is generally attached a lever by which it is turned, and thus fitted up it beeomes a machine of great power and advantage.

The advantage of the screw depends upon the number of turns of the thread in a given distance.

To find the power of the screw.

RULE.—As the circumference of the circle described by the power applied at the end of the lever is to the distance between the threads, so is the power employed to the effect produced.

Example.

What weight can be raised by a screw the distance between the spiral threads of which is 1 inch, and the circumference of the circle described by the power is 20 feet, by a power of 150 lbs? Ans. 3000 lbs.

Remark.—It is a principle of universal application in Mechanics, that what is gained in power is lost in time; from this principle we may derive the following General Rule for Mechanics:

RULE.—As the space passed through by the weight is to the space passed through by the power, so is the power applied to the weight raised, or effect produced.

MENSURATION.

Mensuration comprehends the admeasurement of lines, superfices, and solids, or the ascertaining of dimensions.*

To divide a given straight line into any number of equal parts.

Rule.—Set the given number of parts on B to the length of the line on A, then against 1 on B will be the length of each part on A.

Examples.

1. Suppose a line 100 inches long be divided into 30 equal parts, what is the length of each part? Set 30 on B to 100 on A, and against 1 on B is 3,3 inches, the length of each part, on A, the answer.

2. Suppose a line 80 inches long to be divided into 45 equal parts, what is the length of each part? Set 45 on B to 80 on A, and against 1 on B is 1,7 inches, the length of each part on A, the answer.

To find the area of a square when the sides are given.

Rule.—Set 1 on B to the length of one side on A, and against the other side on B will be the contents, in the dimensions of the sides on A.

* The admeasurement of lines, properly considered, does not belong to Mensuration, it being in general limited to the admeasurement of solids and superfices

Or—set 1 on C to 1 on D, and against the length of one side on D will be the contents, in the dimensions of the sides, on C.

Examples.

1. What is the superficial contents of a square board, the sides of which measure 4 feet each?

By Rule 1st—Set 1 on B to 4 on A, and against 4 on B is 16 square feet, the answer, on A.

By Rule 2d—Set 1 on C to 1 on D, and against 4 on D is 16 square feet on C, the answer as before.

2. What is the superficial contents of a square piece of land, each side of which measures 14 rods? Set 1 on B to 14 on A, and against 14 on B is 196 square rods on A the answer.

Or—Set 1 on C to 1 on D, and against 14 on D is 196 square rods, the answer, on C.

To find the superficial contents of a parallelogram.

Rule.—Set 1 on B to the length on A, and against the width on B will be the contents in dimensions of the sides on A.

Examples.

1. What are the contents of a piece of ground 30 rods long and 12 rods broad? Set 1 on B to 30 on A, and against 12 on B is 360 square rods on A, the answer.

2. What are the contents of a table the length of which is 6 feet, and the breadth 3½ feet? Set 1 on B to 6 on A, and against 3,5 on B is 21 feet on A, the answer.

To find the area of a triangle.

Rule.—Set 1 on B to the length of the base on

A, then against one-half the perpendicular on B will be the contents on A.

Examples.

1. What is the area of a triangle the base of which is 9 feet and the height 7 feet? Set 1 on B to 9 on A, and against 3½ on B is 31½ square feet on A, the answer.

2. What is the area of a triangular piece of ground whose base is 15 rods and one-half the perpendicular is 6½ rods? Set 1 on B to 15 on A, and against 6,5 on B is 97,5 on A, the answer.

To find the area of the circle when the circumference is given.

RULE.—Set ,0795 or ,08 on C to 1 on D, then against any circumference on D will be the area, in the denomination of the circumference on C.

Examples.

1. What is the area of a circle whose circumference is 12 inches? Set ,0795 on C to 1 on D, and against 12 on D is 11½ square inches, the area required, on C.

2. What is the area of a circle the circumference of which is 34½ inches? Let the slider remain set as in the last example, and against 34½ on D is 95 square inches, the area sought, on C.

Remark, 1.—As the slider now stands the lines C and D form a table of circumferences, and areas, for against any circumference on D is its area on C.

Remark 2.—If the circumference is required from the area, all that is necessary is to set the slide according to the foregoing rule, then against

any area on C will be the circumference required on D.

The diameter of a circle given to find the area.

RULE.—Set ,785 on C to 1 on D, and against the diameter on D will be the area on C.

Examples.

1. What is the area of a circle whose diameter is 9 inches? Set ,785 on C to 1 on D, and against 9 on D is 63 1-2 inches on C, the answer.

2. What is the area of a circle the diameter of which is 20 inches? Set ,785 on C to 1 on D, and against 20 on D is 314 square inches, the area, on C, the answer.

The diameter given to find the circumference.

RULE.—Set 1 on B to 3,14 on A, and against the diameter on B will be the circumference on A.

Examples.

1. What is the circumference of a circle whose diameter is 19 inches? Set 1 on B to 3,1 4 on A, and against 19 on B is 59,7, nearly, on A, the answer.

2. What is the circumference of a circle the diameter of which is 40 rods? Set 1 on B to 3,14 on A, and against 40 on B is 125,6 rods on A, the answer.

The circumference given to find the diameter.

RULE.—Set 22 on B to 7 on A, and against the circumference on B will be the diameter on A.

Example.

What is the diameter of a circle whose circumference is 80 inches? Ans 25,4 inches.

The area given to find the diameter.

Rule.—Set ,7854 on C to 1 on D, and against the given area on C will be the diameter required on D.

A SEMICIRCLE,

The arch and diameter given to find the area.

Rule.—Set 1-2 the arch line on A to 1 on B, and against 1-2 the diameter on B will be the area on *A*.

Examples.

1. What is the area of a semi-circular field whose diameter is 22,6 rods and the arch line 35,5? Set 1 on B to 17,7 on *A*, and against 11,3 on B is 200,6 rods, nearly, on *A*, the answer.

2. What is the area of a semi-circular field whose diameter is 40 rods and arch line 62,8? Ans 62,8.

To find the side of a square which shall be equal in area to a given circle.

Rule.—Set I on B to ,886 on *A*, and against the given diameter on B will be the square side required on A.

Examples.

1. What is the side of a square which shall be equal in area to a circle whose diameter is 2 feet? Set 1 on B to ,886 on A, and against 2 on B is 1,77 feet on A, the answer.

2. What is the side of a square which shall be equal in area to a circle whose diameter is 40 rods? Set 1 on *B* to ,886 on A, and against 40

on B is 55,44 rods, the length of the side required, on A, the answer.

3. What is the side of a square stick of timber that shall contain as many cubic feet as a saw-log whose diameter is 25 inches, supposing them to be equal in length? Set 1 on B to ,886 on A, and against 25 on B is 22,15 inches, the side of the stick, on A, the answer.

To find the longest side of a parallelogram when the shortest side and area are given.

RULE,—Set the given side on A to 1 on B, and against the given area on A will be the length of the required side on B.

Example.

1. What is the longest side of a parallelogram the width of which is 4 feet, and its area 48 feet? Set 4 on A to 1 on B, and against 48 on A is 12 feet, the length of the required side, on B, the answer.

2. What is the longest side of a parallelogram, whose area is 225 and its width 12 feet respectively? Set 12 on A to 1 on B, and against 225 on A is 18 3-4 feet on B, the answer.

Remark.—The shortest side may be found in the same way, viz: by setting the longest side on A to 1 on B, and against the area on A will be the shortest side on B.

Example.

The area and longest side of a parallelogram are 50 and 8 feet respectively, what is the length of the other side? Ans. 6,25.

To find the area of an ellipsis.

RULE.—Multiply the longest diameter by the shortest, and that product by ,7854 for the area.

The diameter of a circle being given to find the side of the greatest inscribed square.

RULE.—Set 1 on B to ,707 on A, and against the given diameter on B will be the side required on A.

Example.

What is the side of the greatest square that can be inscribed in a circle whose diameter is 30 inches? Set 1 on B to ,707 on A, and against 30 on B is 21,21 inches, the side required, on A, the answer.

To find the side of the greatest equilateral triangle that can be inscribed in a given circle.

RULE.—Set 1 on B to ,866 on *A*, and against the given diameter on B will be the side required on A.

Examples.

1. What is the side of the greatest equilateral triangle that can be inscribed in a circle whose diameter is 15 inches? Set 1 on B to ,866 on A, and against 15 on B is 13 inches, the side required, on *A*, the answer.

Remark.—It will be observed that as the slider now stands it forms a table of circles and the sides of inscribed equilateral triangles, for against any given diameter on B is the side of the greatest equilateral triangle that can be inscribed in that

circle. This is one of the many advantages of Slide Rule over arithmetical computations, for in many instances where the slide is once set to its proper guage point, a whole series of problems are readily solved, and their relations to others of like nature easily ascertained.

2. What is the side of the greatest equilateral and triangular prism that can be cut from a saw log whose diameter is 30 inches? Ans. 25,98.

SOLIDS.

"Solid Bodies are such as consist of length, breadth and thickness."

To find the number of solid feet contained in a square stick of timber.

RULE.—Set the length on C to 12 (inches) on D, and against the width on one side, (if they are all equal) on D, will be the contents of the stick in feet on C.

Examples.

1. What is the content of a square stick of timber 4 feet long and 30 inches square? Set 4 on C to 12 inches, the guage point, on D, and against 30 inches, the width of one side, on D is 25 feet on C, the answer.

2. What would be the contents of the above stick of timber if it was 40 feet long? Ans. 250.

Remark.—When the sides of the stick are not equal, that is, when the end of the stick is a parallelogram or oblong square, a mean proportion of the sides must be obtained, which must be used

instead of the width of the side, as in the following examples. The mean proportion is found thus:

Set the width of one side on C to the same width on D, then against the width of the other side on C will be the mean proportion sought on D.

Examples.

How many solid feet are contained in a stick of square timber 30 feet long and the sides of which are 20 and 45 inches respectively? Set 20 on C to 20 on D, and against 45 on C is 30 inches, the mean sought, on D :—now set 30 feet, the length of the stick, on C to 12, the guage point, on D, and against 30 inches, the mean proportion, on D is 189 feet, nearly, on C, the ans.

Remark, 2*d*.—When the width of the sides are given in feet instead of inches, set the length on C to 1 (or 10, calling it 1) on D, then against the width of one side, or the mean proportion, in feet, on D will be contents required, in feet, on C.

Example.

How many feet are contained in a beam 25 feet long and 2 ft square? Set 25 on C to 1 on D, then against 2 feet, the width of one side, on D is 100 feet on C, the answer.

Remark, 3*d*.—When the length is given in inches, set the length on C to 1 on D, and against the width of one side, or the mean proportion, in inches on D will be the contents, in inches, on C.

Example.

How many solid inches are contained in a bar of steel 80 inches long, and 3 inches square? Set

80 on C to 1 on D, and against 3 on D is 720 in on C, the answer.

To find the contents of a cylinder.

RULE.—Bring the length on C to 13,54 on D, and against the diameter in inches on D will be the contents in feet on C.

Example.

1. What are the contents of a cylinder 30 feet long and 25 inches in diameter? Set 20 on C to 13,54, the guage point, on D, and against 25 on D is 68 feet on C, the answer.

2. How many feet are contained in a cylinder 15 feet long, and 30 inches in diameter? Set 15 on C to 13,54 on D, and against 30 on D is 73½ feet, nearly, on C, the answer.

3. How many solid feet are contained in a saw log 13 ~~feet long~~ and 20 inches in diameter? Set 13 on C to 13,54 hundredths on D, and against 20 on D is 28½ feet on C, the answer.

Remark.—When the length is given in inches bring the length on C to 1,128, (or 1,13, which in general would be sufficiently accurate) on D, and against the diameter in inches on D will be the contents in inches on C.

Example.

How many inches are there in a cylindrical rod of iron 1-2 inch in diameter and 50 inches long? Ans. 10,2 nearly.

To find the solidity of a pyramid.

RULE.—Set 1-3 of its perpendicular height in feet on C to 12, the guage point, on D, then against

the width of one side of the base, or mean proportion, on D will be the contents in feet, on C.

Examples.

1. What are the solid contents of a pyramid whose height is 15 feet and the side of its base is 4 feet? Set 5 feet, 1-3 of its height, on C to 12 on D, and against 4 feet on D is 80 solid feet on C, the answer.

2. What is the solidity of a pyramid whose height is 27 feet and its base 7 by 9 feet? Set 9 on C to 12 on D, and against 7,8, the mean, on D is 567 feet, nearly, on C, the answer.

Remark.—When the dimensions of a pyramid are given in inches, *i. e.* its height and the sides of its base, set 1-3 of its height on C to 1 on D, and against the width, or the mean proportion, of one side of its base on D, will be the contents in inches on C.

To find the solidity of a cone.

Rule.—Set 1-3 the perpendicular height on C to 13,54 on D, then against the diameter of the base on D will be the contents, in feet and tenths of a foot, on C.

Example.

What is the solidity of a cone, whose height is 24 feet and the diameter of its base is 60 inches? Set 8 on C to 13,54, the guage point, on D, and against 60 inches, the diameter, on D is 156 feet on C, the answer.

Remark.—When the height and diameter of a cone is given in inches, set 1-3 of its height

on C to 1,128 (or 1,13) on D, and against the diameter of the base on D will be the contents, in inches, on C: and if the height and diameter are both feet, the guage point and operation is the same as it is when they are both inches.

Example.

What are the contents of a pyramid and cone respectively, whose heights are 18 inches each, and the sides of the base of one and the diameter of the base of the other are 5 inches each? Ans. the pyramid contains 150, and the cone 117,6 inches respectively.

WEIGHING METALS.

DIRECTIONS FOR USING THE FOLLOWING TABLE.

When the article is feet long and feet square the guage point is found under "*Square*" in the column FFF; when it is feet long and inches square, the guage point is found in column FII; and when it is inches long and inches square, the guage point is found in the column III. When the article is feet long and feet in diameter, the guage point is found under "*Cylinder*" in column FF; if feet long and inches diameter, the guage point is in column FI; if inches long and inches diameter, it is found in column II. For *Globes*, if

feet in diameter, the guage point is found under F, if inches under I.

A TABLE OF GUAGE POINTS

	Square.			*Cylin'r.*		*Globe.*	
	FFF	FII	III	FI	II	F	I
Cubic inches	36	518	624	660	799	625	113
Cubic feet.........	625	9	108	114	138	119	206
Wine, gals........	835	12	145	153	83	16	276
Ale, gals..........	102	147	176	188	224	196	335
Water, in lb.......	10	144	174	184	22	191	329
Oil, in lb..........	108	1565	189	199	238	207	358
Gold, in lb.........	507	735	88	96	118	939	180
Silver, in lb.......	938	136	157	173	208	173	154
Quicksilver, in lb.	738	122	127	132	162	141	242
Brass, in lb........	12	174	207	221	265	23	397
Copper, in lb......	112	163	196	207	247	214	371
Lead, in lb........	880	126	152	162	194	169	289
Wrought Iron, lb..	129	186	222	235	283	247	423
Cast Iron, Spelter lb	139	2	241	254	304	265	458
Tin, in lb.........	137	435	235	25	300	261	454
Steel, in lb.........	136	183	22	233	278	239	418
Marble, in lb	370	53	637	725	81	72	121
Freestone, in lb ...	394	57	69	728	873	755	132
Brick, in lb........	495	72	860	92	10	95	164
Coal, in lb.........	795	114	138	146	176	151	262
Dry Oak, in lb....	108	158	190	2	237	208	355
Mahogany, in lb ..	94	136	164	175	208	18	336
Box Wood, in lb ..	968	152	169	194	214	186	32
Red Deal, in lb ...	151	22	263	285	236	287	501
Bushels, ...	780	112	133	142	172	148	256

Rule.—Set the length on B to the guage point on A, then against the diameter or side of the square on D will be the contents on C.

Examples.

1. How many feet is contained in a stick of timber 6 feet long and 13 inches square? Set 6 on B to the guage point (found in the column FII against feet) on A, and against 13 on D is 7 feet on C, the answer.

2. What are the contents, in feet, of a cylinder 8 feet long and 9 inches in diameter? Set 8 on B to 114, the guage point, (found in the column FI under the head of Cylinder,) on A, and against 9 on D is 3,5 feet on C, the answer.

3. What is the weight of a stick of mahogany 5 feet long and 7 inches square? Set 5 on B to the guage point [found in column FII, under the head of Square, against Mahogany] on A, and against 7 on D is 112 lbs on C, the answer.

4. Required the weight of a piece of cast iron circular 24 inches long and 12 in. diameter? See the preceding table, column FI of Cylinders, in the line Cast Iron, is 304, the guage point; set the length on B to the guage point on A, and against the diameter on D is 708 lbs, the contents, on C.

To find the contents or weight of a globe or ball.

Rule.—Set the diameter on B to the guage point on A, and against the diameter on D will be the answer sought on C.

Example.

1. What are the contents of a globe or ball the diameter of which is 10 feet? Set 1 on B to 119,

the guage point, found in column F, against feet, and under the head of globes, on A, and against 10 on D is ,523 feet on C, the answer.

3. What is the weight of a cast iron globe 12 inches in diameter? See the preceding table under Globe in the column I, and against Cast Iron, is 458, the guage point—set 12, the diameter, on B to 458 on A, and against the diameter on D is 235 lbs on C, the answer.

2D—TABLE OF GUAGE POINTS,

For weighing the several articles contained therein by the lines C and D.

	Guage Points for Squares.	Guage Points for Circles.
Cast bars of iron	1,19	2,21
Wrought bars of Iron.....	1,875	2,125
Brass	1,82	2,05
Steel.....................	1,875	2,12
Lead......................	1,5675	1,76

RULE.—Set the length in inches on C to the guage point on D, and against the mean square or diameter on D will be the weight in lbs on C.

Example.

What is the weight of a cast bar of iron 25 inches long and 3 inches square? Set 25 on C to 1,19 on D, and against 3 on D is —— lbs on C, the answer.

GUAGE POINTS FOR GLOBES.

Cast Iron	2,71
Wrought iron	2,625
Brass	2,56

RULE.—Set the diameter in inches on C to the guage point on D, and against the diameter in inches on D will be the weight in lbs on C.

Example.

What is the weight of a cast iron globe or ball 4 inches in diameter? Set 4, the diameter, on C to 271, the guage point, on D, and against 4, the diameter, on D is — lbs on C, the answer.

COMPARISON OF SOLID BODIES.

If a stick of timber 25 inches square and 20 feet long, be taken for the standard, how many times will it be contained in a stick 40 inches square of the same length? Set 1 on C to 25 on D, then against 40 on D is 2,6, that is, two and six-tenths times on C, the answer.

How many sticks of the dimensions of the standard are contained in one which is 90 inches square? Let the slide stand as in the last, and against 90 on D is 13 on C, the answer.

A saw-log 20 inches in diameter is usually taken for the standard, and is called "one log;" in that case how many logs are contained in one whose diameter is 40 inches? Set 1 on C to 20, the standard, on D, and against 40 on D are 4 on C, the answer.

From the above examples we may deduce the following

RULE.—Set 1 on C to the width of one side for square timber, and to the diameter for round, of the standard, on D, then against the side of any square stick of timber, or the diameter of any log or cylinder, on D, will be the proportion it bears to the standard on C.

Example.

A grindstone 24 inches in diameter, and 4 inches thick is usually taken for the standard, or called one stone; in that case how many stones are contained in one whose diameter is 30 inches? Set 1 on C to 24 on D, and against 30 on D is 1,56 or one stone and a half, on C, the answer.

Note.—If the stone is 8 inches in thickness it must be doubled to obtain a correct answer.

If two men own a grindstone 19 inches in diameter, and *A* owns six-tenths and *B* four-tenths, to what diameter must *A* grind to get his share of the stone? Set 1 on C to 19 on A, and against 4-10 on C is 12 inches on D; therefore A grinds till the stone is 12 inches in diameter.

To determine the relative price of a saw-log.

RULE.—Set the price of the standard log on C to its diameter on D, then against the diameter of any other log on D will be its price on C.

Examples.

If a saw-log 20 inches in diameter is worth 80 cents, what is one of the same quality worth whose diameter is 30 inches? Set 80 on C to 20 on D, and against 30 on D is 180 cents on C, the answer.

What is one worth whose diameter is 40 inches? Ans. 320 cents.

What is one worth the diameter of which is 10 inches? Ans, 20 cents.

What is one worth whose diameter is 8 inches? Ans. 12 cents 8 mills.

If a stick of timber 18 inches square and 20 feet long is worth $5, what is one of the same length and 25 inches square worth? Set 5 on C to 18 on D, and against 25 on D is 9 dollars and 65 cents on C, the answer.

DRY MEASURE.

Dry Measure is used in measuring grain, coal ashes, &c.

The following is a table of guage points for Dry Measure:

	Guage Points for Squares.	Guage Points for Circles.
Guage point for a bushel 1 foot long	.13,387	15,11
do do 1 inch deep .	46,37	52,32
do for coal at 40 qts per bushel, 1 foot deep . .	14,996	16,89
do for ashes and coal at 38 qts per bush, 1 ft deep .	14,59	16,62
do for a peck, 1 in deep.	23,18	
do half bush, 1 in deep .	32,79	
do half peck, 1 in deep .	16,39	
do for 2 qts, do .	11,59	
do for 1 qt, do .	8,19	

Rule.—Bring the length of the vessel on C to its guage point on D, then against the width of one side if square, or the diameter if a circle, on D will be the contents in bushels, quarts, &c. as the case may be, and tenths of a bushel, quart, &c. on C.

Examples.

1. How many bushels of grain will a box contain which is 5 feet long and 20 inches square on the inside? Set 5 on C to 13,39, the guage point, on D, then against 20 on D is 11,3 bushels on C, the answer.

Remark.—If the box or vessel is deeper than it is broad, or *vice versa*, a mean proportion must be taken and used instead of either the breadth or depth.

2. How many bushels of grain are there in a cylinder 8 feet long and 22 inches in diameter? Set 8 on C to 15,11, the guage point, on D, and against 22 on D is 17 bushels on C, the answer.

3. How many pecks are contained in a box 3 feet long and 25 inches square? Set 36, the length in inches, on C to 23,18 on D, and against 25 on D is 41 pecks on C, the answer.

4. How many quarts are contained in a box 20 inches long and 12 inches square? *Ans.* 43, nearly.

LIQUID MEASURE.

Liquid Measure is used in measuring liquids of various kinds, such as ale, beer, wine, &c.

The following is a table of guage points for measuring the various kinds of liquors mentioned therein:

	Guage p'ts for Sq's.	Guage p'ts for Cir's.
A guage point for an ale gallon, (it being the side of a square vessel, and the diameter of a cylinder 1 inch deep) containing one gallon	16,79	18,95
Guage point for two quarts .		13,39
do for one quart . .	8,39	9,47
do for a pint . . .	5,93	6,69
do for a half pint . .	4,19	4,73
do for a wine gallon .	15,20	17,15
do for a London ale bbl	94,99	107,19
do do beer bbl .	100,75	113,63
do for an ale and beer barrel containing 34 gallons	97,9	110,48

Rule.—Set the length on C to the proper guage point on D, then against the side of the vessel or the diameter of the given cylinder on D will be the contents in gallons, quarts, barrels, &c,. as the case may be, on C.

Remark.—The length of the vessel must be reduced to inches.

Examples.

1. How many ale gallons will a vessel contain which is 36 inches long, and 20 inches square? Set 35 on C to 16,79, the guage point, on D, then against 20 on D is 51,5 gallons, nearly, on C, the answer.

2. How many wine gallons will a cylindrical vessel contain which is 30 inches long and 20 inches in diameter? Set 30 inches on C to 17,15 on D, and against 20 on D is 41 gallons, nearly, on C, the answer.

3, How many barrels are contained in a cylindrical vessel 50 inches long and 25 inches in diameter? Set 40 on C to 107,19, the guage point for London ale barrels, on D, and against 25 on D is 2,44 barrels on C, the answer.

Remark.—It must be borne in mind that when the vessel is parallelopiped, and is deeper than it is broad, a mean proportion must be used instead of either side.

CASK GUAGING.

The liquid contents of casks are found after a mean proportion is found between the bung and head diameters, which reduces the cask to a cylinder, when the operation is performed as before directed for finding the liquid contents of cylinders.

Casks are divided into four varieties. If the difference between the head and bung diameters does not exceed 6 inches the mean diameters of the several varieties may be found by multiplying the difference of the first by ,68, the second by 62,

the third by ,55, and the fourth by ,5; the respective products of these numbers added to the head diameter of the respective varieties will give the mean required.

Examples.

1. If the bung and head diameters of a cask are 28 and 24 inches respectively, and the length is 30 inches, how many ale gallons will it contain? Bring the length on B to 224, (see table page 94) the guage point, on A, then against the mean diameter on D are 59,73 ale gallons on C, the ans.

2. What are the contents in wine gallons of a cask whose bung diameter is 35 inches, head 27 inches, and length 45 inches? Set the length on B to 83, the guage point, (found in table on p. 94) on A. then against 32,6, the mean diameter, on D are 162,66 gallons on C, the answer.

3. What are the contents in ale gallons of a cask of the third variety, whose head and bung diameters are 20 and 26 inches respectively, and its length 29 inches? Bring the length on B to 224, the guage point (found in the table on p. 94) on A, and against 23,3, the mean diameter, on D are 43,8 ale gallons on C, the answer.

BOARD MEASURE.

To find the contents of a board, the length and breadth being given.

Rule.—Bring the length in feet on B to 12,

the guage point, on A, then against the width, in inches, on A, will be the contents in feet on B.

Examples.

1. How many feet are there in a board which is 13 feet long and 15 inches wide? Set 13 on B to 12, the guage point, on A, and against 15 on A is 16,15 feet on B, the answer.

Remark, 1*st*.—As the slider now stands the line B forms a table of contents, for against any width of board of the given length on A is the contents of that board on B.

Remark, 2*d*.—If the width of the board is given in feet, bring the length in feet on B to 1 on A, then against the width in feet on A will be the contents in feet on B.

2. How many inches in width must be cut from a board 10 feet long and 14 inches wide to make 5 feet board measure? Set 10 on B to 12 on A, and against 5 on B is 6 inches on A, the answer.

MEASUREMENT OF WOOD.

The guage points for measuring wood on the Engineer's Rule, FFF 128, FII 185, nearly; 144 for the guage point when you wish to get it in cubic feet—or for the common Sliding Rule use

for guage points FFF 8, FII 115, nearly, for cubic feet FII 9 on A.

Examples.

1. How much wood is there in a load of wood 7 feet 6 inches long, 4 feet 8 inches wide, and 4 feet high? Ans. 140 feet, or 1 cord 12 feet.

Operation.—First find the mean square, reduce the feet to inches, call it inches—4 feet 8 inches = 56 inches; 4 feet =48 inches: set 56 on C to 56 on D, and against 48 on C will be found 51,86, nearly, on D—set the length 7,5 on B to 144 on A, then against 51,86 on D will be found 140 feet on C, or 1 cord 12 feet.

2. How much wood in a pile measuring 8 feet on every side? Set 8 on B to 128 on A for the Engineer's Rule, or 8 for the Common Rule, and against 8 on D will be found 4 on C, the answer.

3. How many cords in a pile of wood 4 feet wide, 6 feet high, and 12 feet long? First find the mean square by setting 6 on C to 6 on D, and against 4 on C will be 4,9 on D, the mean square: set 12 on B to 128 on A, or for the Common Rule 8 is the number to be set to, then against 4,9 on D will be found 2,25 on C, the answer.

4. How many solid feet in a pile of wood 8 feet long, 3 feet wide, and 2 feet 8 inches high? Reduce the feet to inches: 3 feet=36, 2 feet 8 inches =32; set 32 on C to 32 on D, then against 36 on C will be found 3,4—set 8 on B to 144 on A, or the Common Rule to 9, then against 3,4 on D will be found 64 feet on C, the answer.

OF LOGS FOR SAWING.

To find the number of feet of boards which can be sawed from any log whatever.

For the Engineer's Rule set the length on B to to 235 on A, and against the diameter on D will be the answer on C.

For the Common Sliding Rule set the length to 147 on A, and against the diameter on D will be the answer on C.

Examples.

1. How many feet of square edged boards can can be sawed from a log 19 feet long and 27 inches diameter? Set 19 on B to 235 on A, and against 27 on D is 589 on C—or, for the Common Rule, set 19 on B to 147 on A, and against 27 on D is 589 on C.

2. How many feet can be cut from a log 20 feet in length and 20 inches in diameter? Set 20 on B to 235 on A, and against 20 on D is 340 on C—or, for the Common Sliding Rule, set 20 on B to 147 on A, and against 20 on D is 340 on C, the answer.

3. How many feet can be cut from a log 16 feet long and 20 inches in diameter? For the Engineer's Rule, set 16 on B to 235 on A, and against 20 on D is 272 on C—or for the Common Rule, set 16 on B to 147 on A, and against 20 on D will be found 272 on C, the answer.

FALLING BODIES.

The time occupied by a falling body being given, to find the space passed through.

RULE.—Set 16 1-12 (say 16,1) on C to 1 on D, then against the time occupied by the falling body in seconds on D, will be the space fallen through, in feet, on C.

Example.

1. How far will a body have fallen at the end of the 2d second, if not retarded in its fall? Set 16,1 on C to 1 on D, and against 2 on D is 64,5 feet on C, the answer.

2. How far will the before mentioned body have fallen at the end of the 3d second? Ans. 144,9. How far at the end of the 4th second? Ans. 257,5. How far at the end of the 6th second? Ans. 579,5.

Remark.—As the slider now stands the lines C and D form a table of times and spaces for falling bodies, for against the time occupied by a falling body on D will be the space it has passed through on C, and *vice versa.*

The fall of a river or any body of water in motion may be ascertained as follows: Set 64 on C to 64 on D, then against the given velocity in seconds on D will be the fall on C.

Examples.

1. Suppose a piece of drift wood were carried down a stream 15 feet in one second, what is the

fall? Set 64 on C to 64 on D, and against 15 on D is 3,5 on C, the answer.

Remark.—The velocity of water spouting through a sluice or aperture in a reservoir or bulkhead is the same that a body would acquire by falling through a perpendicular space equal to that between the top of the water in the reservoir and the aperture.

2. If the velocity of a stream issuing through the bulkhead of a mill be 16 feet per second, what head of water is there? Set 64 on C to to 64 on D, and against 16 on D is 4 on C, the answer.

3. What is the velocity of water issuing from a head of 5 feet? Set the slider as in the last example, then against 5 on C will be 18, nearly, on D, the answer.

4. There is a sluice or flume one end of which is 2,5ft. lower than the other, what is the velocity of the stream per second? Set 64 on C to 64 on D, then against 2,5 on C will be found on 12,64 feet on D, the answer.

PENDULUMS.

The number of vibrations given to find the length of pendulum.

Rule.—Invert the slider and set 39,2, the first guage point, on B to 60, the second guage point,

on D, then against the given number of vibrations on D will be the length of pendulum required on *B*.

Examples.

1. What will be the length of a pendulum that will make 120 vibrations in a minute? Invert the slider, and set 39,2 on B to 60 on D, then against 120 on D is 9,8 inches, the length required on B.

Remark.—As the slider now stands, the lines B and D form a table of inches and vibrations to any desired extent; for against any number of vibrations in a minute on D is the corresponding length of pendulum in inches on B, and *vice versa*, thus:

Against	30	vibrations	on D are	15,7	inches	on B.
"	40	"	"	88,5	"	
"	50	"	"	56,5	"	
"	60	"	"	39,2	"	
"	70	"	"	28,8	"	

MACHINERY.

The diameters of two wheels or pulleys, which work together, and the velocity of one of them being given, to find the velocity of the other.

Rule.—Invert the slider and set the diameter of one of the wheels or pulleys on C to its velocity

on *A*, then against the diameter of the other wheel will be its velocity on A.

Example.

1. What is the velocity of a pulley 12 inches in diameter that works with another 20 inches in diameter, when the latter makes 40 revolutions in a minute? Invert the slider, and set 20 on C to 40 on A, and against 12 on C is 66,5 (or 66 1-2) revolutions in a minute on A, the answer.

Remark, 1*st*.—The relative velocity of two pulleys may be ascertained by setting the diameter of one of them on C to 1 on *A*, then against the diameter of the other on C will be their relative velocity on *A*.

Example.

What is the relative velocity of the pullies mentioned in the last example? Invert the slider, as in the last example, and set 20 on C to 1 on A, and against 12 on C is 1,68, the relative velocity required, on *A*—*i. e.* as 1 is to 1,68.

Remark, 2*d*.—In cog work the number of teeth in the different wheels may be used instead of their diameters.

The separate velocities of two wheels, together with the diameter of one being given, to find the diameter of the other.

Rule.—Invert the slider and set the given velocity of the wheel of the given diameter on C to the given diameter on A, then against the velocity of the other on C will be the diameter required on *A*.

Examples.

What is the diameter of a pulley whose velocity is to be 30 revolutions in a minute, that works with another the diameter of which is 10 inches and makes 20 revolutions in the same time? Invert the slider and set 20 on C to 10 on A, and against 30 on C is 6,66 inches on A, the answer.

Remark.—All others of like nature may be solved in the same way.

The distance between two shafts and the number of their revolutions given, to find the diameters of two wheels which will turn them at given velocities.

Rule.—Add the revolutions of the shafts together and set their sum on B to the distance between the shafts on *A*, then against the revolutions of one shaft on B will be the semi-diameter of the wheel to be attached to the other shaft, on A.

Example.

The ply shaft of a steam engine, making 22 revolutions in a minute, is to give motion (by a pair of spur wheels) to the tumbling shaft in the mill, which is to be turned exactly 15,5 times in the same time, when the distance between the two shafts is 45,5 inches, the diameter of the two wheels are required. Set 37,5. the sum of the revolutions, on B to 45,5, the distance between the shafts, on A, and against 22, the revolution of the ply shaft, on B is 26,75 inches on A for the tumbling shaft wheel, and against 15,5 on B is 18,75 inches for the ply shaft wheel--*i. e.*, their semi-diameters—for the answer.

To find the number of cogs or teeth in a wheel, having the pitch of the tooth and diameter given.

RULE.—Set the pitch of the tooth on B to 3,14, the guage point, on A, then against the diameter on B will be the number of cogs required on A.

Example.

How many teeth or cogs must there be in a wheel 40 inches in diameter at the pitch line when the pitch of the tooth is exactly 2 inches? Set 2, the pitch of the tooth, on B to 3,14, the guage point, on A, and against 40, the diameter, on B are 63 cogs on A, the answer.

The pitch and number of teeth given, to find the diameter.

RULE.—Set the pitch of the tooth on B to 3,14 on A, then against the number of cogs on A will be the diameter on B.

Example.

What must be the diameter at the pitch line when there are to be 21 teeth, and the pitch of the tooth is 2 inches? Ans. 13,4 inches.

The diameter at the pitch line and the number of teeth given, to find the pitch of the tooth.

RULE.—Set the diameter at the pitch line on B to the number of teeth on A, then against 3,14, the guage point, on A will be the pitch of the tooth on B.

Example.

If a wheel 70 inches in diameter is to have 146 th, what will be the pitch of the tooth? Set 70

on B to 146 on A, and against 3,14, the guage point, on A, is 1,5 (or 1½) inches on A, the ans.

GENERAL RULE FOR CALCULATING SPEED OF ALL KINDS, BY NUMBERS.

Separate all the driving wheels or pulleys from the driven. and if wheels multiply the number of teeth, but if pulleys or drums multiply the diameters of all the drivers together, and the product by the speed given; then multiply all the diameters or teeth of the driven together and divide the product of the former by the product of the latter, and the quotient will be the speed sought.

Remark.—The *speed given* are the revolutions per minute of the water wheel or main shaft.

STEAM ENGINES.

To find the power of a Steam Engine.

RULE.—Robert McQueen says that a 30 inch cylinder and 4 feet stroke, exclusive of its piston, is equal to 30 horse power. Taking this for a standard, set 30 on C to 30 on D, then against the diameter of any other cylinder, of equal stroke, on D will be its horse power on C.

Examples.

What is the power of an engine whose cylin-

der is 20 inches in diameter? Set 30 on C to 30 on D, and against 20 on D is 13,4 horse power on C, the answer.

What is the power of one of a 10 inch cylinder? Let the slider remain as in the last example, and against 10 on D is 3,35 on C, the answer. What of a 6 inch? Ans. 1,2. What of a 35 inch? Ans. 40 5-6.

Mr. Perkins constructed a steam engine, the cylinder of which was only 2 inches in diameter and 18 inches long, leaving a stroke of 12 inches, that was equal to a ten horse power. If this is taken for the standard, set 10 on C to 2 on D, then against the diameter of any other cylinder of the same length or stroke on D will be its power on C.

To find the dimensions of a steam pan or boiler sufficient to supply with steam a cylinder of any given diameter.

Rule.—Set 1,3, the guage point, on C to 1 on D, then against any diameter of cylinder in inches on D will be the dimensions required in feet on C.

Remark.—The dimensions given by the above rule are the superficial contents or *surface* of the water in the boiler, and not the solid contents as some might suppose.

Examples.

How many superficial feet must be contained in the area of a boiler to supply a cylinder 43 inches in diameter? Set 1,3 on C to 1 on D, and against 43 on D is 240 square (not solid) feet of surface on C, the answer.

As the slider now stands we have the following

TABLE.

For against the	15	....	29,2	these areas
	20	....	52	
following diam-	25	....	81	in superfi-
	30	are	117	
eters in inches	35	....	160	cial feet
	40	....	207	
on the line D,	55	....	264	on C.

MISCELLANY.

Containing the Solution of Problems not found in the foregoing.

LAND OR SQUARE MEASURE.

The guage points for Land are the number of square chains, square perches, square yards, &c., that are contained in an acre, and are as follows:

For chains it is 1 or 10
For rods, 160
For yards, 4840

RULE.—Set the length on B to the guage point on A, then against the width on A will be the contents on B.

Examples.

1. How many acres are there in a field 20 chains and 50 links in length, and 4 chains and

40 links in breadth? Set 20,5 (fifty links being fifty-hundredths or five-teuths) on B to 1 on A, and against 4,4 on A are 9,2 aeies on B the ans.

2. What are the contents of a field the length of which is 142 and the breadth 40 rods? Set 142 on B to 160, the guage point, on A, then against 45 on A are 40,04 acres on B, the answer.

3. What are the contents of a field 440 yards long and 44 broad? Set 440 on B to 4840, the guage point, on A, then against 44 on A are 4 acres on B, the answer.

A solid foot of round timber will cut eight feet of boards—supposing all round timber to cut boards in this proportion, the number of feet that can be cut from a given saw log may be found by setting 1 on B to 8 on *A*, then against the number of feet in the given log on B will be the number of feet on A.

Example.

How many feet of boards will a saw log cut which contains 200 solid feet? *Ans.* 1600.

Four acres in a square form will be 40 rods on each side—therefore, to find the number of acres in any lot in a square form set 10 on C to 40 on D, then against the side of any other lot in a square form on D, will be the contents of the same in acres, on C.

Examples.

How many acres are there in a lot of land 80 rods square? Set 10 on C to 40 on D, then against 80 on D are 40 acres on C, the answer.

The diameter of a circle containing an acre is

14,28 rods—how many acres are there in a circle whose diameter is 30 rods? Set 1 on C to 14,28 on D, and against 30 on D is 4,4 acres on C, the answer.

How many bushels are contained in a bin 25 inches square and 1 foot deep? Set 13,38, the guage point, on D to 1 on C, and against 25 on D are 3,5 (or 3½) bushels on C, the answer.

If the above bin be 40 inches long instead of being square, what must be its width to contain the same quantity? Invert the slider and set 25 on C to 25 on A, and against 40 on C are 15,625 inches for the width of the bin on A, the answer.

Annexed is a table of guage points to find the areas of equilateral and regular polygons.

Rule.—Set the guage point on C to 1 on D, then against the length of one side of the given polygon on D is the area on C.

Example.

What is the area of an equilateral triangle each side of which is 12 inches? Set ,433, the guage point, on C to 1 on D, and against 12 on D is 62,5 (62½) on C, the answer.

No. of sides.	Guage points.
3	,433
4	1,000
5	1,720
6	2,598
7	3,634
8	4,828
9	6,182
10	9,694
11	9,366
12	11,195

2. What is the area of a polygon with 7 sides, each of which is 3,5 inches? Set 3,364 on C to 1 on D, and against 3,5 on D is 44,6 inches on C, the area required.

3. What is the area of a 10 sided figure each side of which is 5 inches long? Set 7,694, the guage point, on C to 1 on D, then against 5 on D is 192 on C, the answer.

Remark.—All other areas are found in the same manner.

If 4 cwt. of iron cost 26 shillings how much will 30 tons cost? Set 4 on B to 26 upon A, and against 30 upon B are £195 on A, the answer.

Remark.—As the slider now stands, against any number of tons on B will be their cost in pounds on A, at 26 shillings per cwt.

How many superficial feet are contained in a board 15 inches long and 5 broad? Set 15 on B to 144, the guage point, on *A*, and against 5 on *A* are ,52 (or ½) feet on B, nearly, the answer.

If a water wheel 30 feet in diameter revolves at the rate of 6 feet in 1 second, how many seconds will it take to make one revolution? The circumference of a circle whose diameter is 30 feet is 94,28 feet—therefore set 6 on B to 1 on A, and against 94,28 on B are 15,71 seconds on A, the answer.

GRINDSTONES.

Four men by a grindstone 60 inches in diameter; how much of its diameter must each grind off to have an equal share of the stone, if the first grind his share, and then another, till the stone is ground away, making no allowance for the eye? Set 4, the number of shares, on C to 60 on D, then against 3 on C are 51,96 inches (the diameter of the stone after the first man has ground his share)

on D; then against 2 on C are 42,426 inches (the diameter left by the second man) on D; and against 1 on C are 30 inches (the diameter left by the third man) on D.

From this example we may deduce the following RULE.—Bring the whole number of shares on C to the diameter on D, then against the number of any share on C will be the diameter of that share on D.

Examples.

1. If three men own a grindstone 40 inches in diameter in equal shares, what is the diameter of the stone when each man receives it to grind off his share? Set 3 on C to 40 on D, then against 3 on C is 40 on D; against 2 on C are 32,48 inches on D; and against 1 on C are 23,4 inches on D, the answer.

2. What would be the several diameters of the several shares of the above stone if its diameter were 50 inches? Set 3 on C to 50 on D, then against 3 on C are 50 inches on D; against 2 on C are 27,8 inches nearly, on D, the answer.

Remark.—If the several shares are expressed in dollars and cents, set the whole cost of the stone on C to its diameter on D, then against any share in dollars and cents on C will be the diameter which that share leaves the stone on D.

Example.

If two men own a grindstone 19 inches in diameter for which one paid $4 and the other $6, what will be the diameter of the stone when the first man has ground off his share? Set 10 on C

to 19 on D, then against 4 on *C* are 12 inches on D, the answer.

LEVERS.

A lever or beam that is 72 inches long, one end of which makes a stroke of 18 inches, while the other passes a space of 30 inches, how far from either end is the fulcrum situated? Set 48, the sum of the strokes, on B to 72, the length of beam on A, and against 18 and 30 on B is 27 and 45, the distance from the respective ends, on A, the answer.

ENGINEER'S IMPROVED SLIDING RULE.

This Instrument may be used like the common Sliding rule in every respect; and resembles it in every particular, excepting the girt-line which commences at 1 and runs to 10, which arrangement gives it a few advantages over that instrument: it also has a table of guage-points, [for weighing and measuring the several articles mentioned in it,] in the place of the draughting scale, previously described.

This table is used entirely for measuring and weighing *solid* bodies; particularly *squares*, *cylinders* and *globes*, which names are placed over their respective guage-points; those are three guage-points for squares, two for cylinders and two for globes;—when the length and both the squares of cubical bodies are given in feet, the guage-point is found under F, F, F, against the given article mentioned at the left hand; if the length is given in feet, and both the squares in inches, the guage-point is found under F, I, I,; if the length and both the squares are given in inches, then the guage-point is under I, I, I,;—for *cylinders*, when the length is in feet and the diameters in inches, the guage-point is under F, I,; but if the length and diameter are both in inches, the guage-point is under I, I,;—*globes*, having but one dimension,

that is, their diameters, the guage-point is always found, if the diameter is in feet, under F, but if in inches, under I.

MENSURATION.

For the use of the before described table we have the following *general Rule*, for squares and cylinders. Set the length upon B to the guage-point upon A, then against the square or diameter upon D will be the contents upon C.

The general *Rule* for globes is as follows:—Set the guage-point upon A to the diameter upon B, then against the diameter upon D will be the contents upon C.

Remark, 1*st*.—It may be well to observe that in using the above described table, the lengths of articles must in all cases be set on B to the guage-point on A, and that the answer will *always* be found on C opposite the square or diameter, as the case may be, on D.

Remark, 2*nd*.—In measuring or weighing square timber, stone, metals, or any other solid bodies that are unequal sided, a mean proportion must be found, in a manner before described.

Examples.

I. What are the contents of a piece of timber 3 feet square and 20 feet long?—The dimensions

being all feet, the guage-point is found under F, F, F, to be 1; therefore set 20 upon B to 1 upon A, and against 3 upon D is 180 feet upon C, the answer.

2. What would be the contents if the dimensions of the above piece was given in inches?—in this case, the guage-point is found under I, I, I, to be 1728; set 240, the length in inches, on B to 1728 upon A, and against 36, the square, [i. e. 3 times 12] upon D is 180 feet upon C, as before.

3. What is the contents of a stick of timber 16 inches broad, 6 inches thick and 20 feet long?

Having found the mean proportion between the sides, look for the guage-point under F, I, I, where it will be found to be 144, then set 20 upon B to 144 upon A, and against 9, 8, the mean proportion, upon D is 13, 3 cubic feet upon C, the answer.

4. How many cubic inches are there in a cylinder 6 inches long and 6 inches in diameter?

The guage-point for cubic inches is 1273, consequently set 6 upon B to 1273 upon A, and against 6 upon D are 169 cubic inches upon C, the answer.

5. How many cubic feet are contained in a cylinder that is 6 feet and 6 inches long and 20 inches in diameter?—Set 6, 5, upon B to 1833, the guage-point, upon A, and against 20 upon D are 142 cubic feet upon C, the answer.

6. What will be the contents of a cylinder, globe and cone, respectively; the cylinder 12 inches high and 12 inches in diameter, the globe also 12 inches in diameter, and the cone 12 inches high and 12 inches in diameter at the base?

1st. Set 12 upon B to 1273, for the cylinder, on A, and against 12 upon D are 1356 cubic inches on C, the answer.

2d. Set 12 on B to 191, for globe, upon A, and against 12 upon D are 904 cubic inches upon C, the answer.

3d. For the contents of the cone take one-third of its height, that is, 4 inches, and set it on B to 1273, the round guage-point, upon A, and against 12 upon D are 452 cubic inches, on C, the answer.

Remark.—The proportions between a cylinder and its inscribed globe and cone, are as the numbers 1, 2, 3, respectively.

WEIGHING METALS.

The weighing of metals is performed in the same manner and on the same principles as that of measuring different commodities, as before described.

General Rule.—*Set the length of the article in feet on B to the guage point on A, and against one side of the square in feet, or diameter in inches, on D will be the answer on C.*

		Square, side in ft.	Cylinder, diam. in in.
The guage point for cast iron is		32	489
do	wrought iron,	279	453
do	brass,		424
do	brass, [globes]	637	

Examples.

1. What is the weight of a piece of cast iron 6 feet long and 3 inches square? Set six upon B to 32, the guage point, upon A, and against 3 on D are 168 lbs upon C, the answer.

2. What is the weight of a cylinder of cast iron that is 6 inches in diameter? Set 6 upon B to 489 upon A, and against 6 upon D are 44 lbs on C, the answer.

3. What is the weight of a bar of wrought iron 12 feet long and 1,5 inches square? Set 12 on B to 297, the guage point, on A, then against 1,5 on D are 91 lbs on C, the answer.

LIQUID MEASURE.

	Guage p'ts for Sq's.	Guage p'ts for Cir's.
The guage for old gallons is, for wine		245
For imperial do		294
For old ale do	282	299
For imperial do	.2773	294

Examples.

1. How many old and imperial wine gallons are there in a column or water 12 feet high and 14 inches in diameter? Set 12 on B to the respective circular guage points for old and impe-

rial measure, on A, and against 14 upon D are 96 old and imperial gallons on C, the answer.

2. What number of old ale and imperial gallons are contained in a column of water 300 feet long and 12 inches in diameter? Ans. 1440 old and 1464 imperial.

3. How many old and imperial ale gallons will a vessel that is 36 inches long and 24 inches square contain? Set 36 on B to the respective square guage points for old and imperial measure, on A, and against 24 on D are 73,5 old, and 74,5 imperial gallons, on C, the answer.

MALT MEASURE.

	Guage p'ts for Sq's.	Guage P'ts for Cir's.
The guage point for a malt bushel is for old measure .	2150	2738
For imperial	2218	2824

Examples.

1. How many old and imperial bushels are contained in a bin 72 inches long, 48 inches broad and 1 inch deep? Set 72, the length, on B to the respective guage points on A, and against 48 on A are 1,6 bushels on B, the answer for old, and 1,558 for imperial. These results multiplied by the number of inches the bin is high, if it happens to be more than 1, will give the number of bushels it will contain.

2. How many bushels of the different measures are contained in a round cistern 32 inches deep and 60 inches in diameter? Set 32 upon B to the guage points on A, and against 60 on D are 42,07 old, and 40,75 imperial bushels on C, the answer.

MENSURATION OF SQUARE BOXES.

1. How many wine gallons in a box 3 feet in length and 20 inches square? Set 3 feet, the length, on B to the guage point found on the rule, which is 1925, then against 20 on D will be found 62,5 on C, the answer.

2. How many ale gallons in a box of the same dimensions? Set 3 on B to 235 on A, and against 20 on D will be found 51 nearly, on C, the ans.

3. How many bushels are contained in a box of the above dimensions? Set 3 on B to 179 on A, and against 20 on D will be 6,67 bushels on C, the answer.

OF GLOBES.

1. How many gallons are there in a globe 3 feet in diameter of wine measure? Set 3 on B to 235 on A, and against 3 on D will be found 114,4 on C, the answer.

2. How many ale gallons in a globe of the same dimensions? Set 3 on B to 312 on A, and against 3 on D is 86,5 on C, the answer.

3. How many bushels in a globe 3 feet in diameter if filled with wheat? Set 3 on B to 267 on A, and against 3 on D will be found 10,5 bushels on C, the answer.

PUMPING ENGINES.

The two following tables of guage points are for finding the diameters of steam cylinders that will work pumps from 3 to 30 inches in diameter, and at any given depth in yards. The first table loads its cylinders with 10 lbs upon every square inch of area in their pistons. The second table is calculated so as to load the different cylinders with 7 lbs weight upon every square inch in the area of their pistons.

TABLE OF 10 LBS.				TABLE OF 7 LBS.			
Dia. of pumps.	Guage points.	Dia. of pumps.	Guage points.	Dia. of pumps.	Guage points.	Dia, of pumps.	Guage points.
3	115	17	367	3	165	17	528
4	204	18	41	4	292	18	591
5	318	19	46	5	457	19	695
6	458	20	51	6	66	20	731
7	625	21	562	7	89	21	81
8	815	22	616	8	117	22	885
9	103	23	67	9	148	23	97
10	127	24	732	10	183	24	406
11	154	25	795	11	222	25	114
12	183	26	86	12	264	26	124
13	2125	27	928	13	308	27	134
14	25	28	99	14	358	28	143
15	2875	29	107	15	412	29	154
16	327	30	115	16	468	30	165

RULE.—Set 1 on B to the guage point on A, and against the given column of water in yards on C will be the diameter of the steam cylinder to work the pump on D.

Example.

What will be the diameter of a steam cylinder sufficient to work a pump 16 inches in diameter and 20 yards deep, the piston being loaded with 10 lbs upon the square inch? Ans. 25½ inches.

Remark.—As the slider now stands the lines C and D form a table of yards of pump 16 inches in diameter, and diameters of cylinders sufficient to work that pump—thus:

Against	15		22,1	inches diam.
	20		25,5	
yards	25	are	28,5	of cylinder
	30		31,3	
on C	35		33,8	on D.

2. What will be the diameter of a cylinder sufficient to work a pump 12 inches in diameter and 25 yards deep, to be loaded with 7 lbs to the square inch? Set 1 on B to 264 (the guage point, found in table second) on A, and against 25 yards on C is 28,5 inches diameter of cylinder on D, the ans.

Remark.—Now against any length of pump 12 inches in diameter to be loaded with 7 lbs on the inch on C will be the diameter of the cylinder to work the same on D—thus:

Against	15		19,8	inches diam.
	20		23	
yards	25	are	25,6	of cylinder
	30		28,1	
on C	35		30,4	on D.

PISTON OF A STEAM ENGINE.

To find the length of stroke up and down when the feet travelled by the piston and number of strokes are given.

RULE.—Set the number of strokes per minute on A to the number of feet the piston travels per minute on B, then against 1 on *A* will be the length of stroke required on B.

Example.

If a piston travel 220 feet per minute and makes 27½ strokes in the same time, what is the length of one stroke? Set 27½ on *A* to 220 on B, and against 1 on B will be 8 feet on A, the answer.

The feet travelled per minute by the piston and length of stroke given to find the number of strokes per minute.

RULE.—Set the length of stroke on B to 1 on A, and against the number of feet travelled in a minute on B will be the length of stroke on *A*.

Example.

If the stroke is 8 feet and the travel of the piston is 220 feet per minute, what are the number of strokes per minute? Ans. 27½.

The length and number of strokes given to find the feet travelled per minute.

RULE.—Set 1 on A to the length of stroke on B, then against the number of strokes on A will be the feet travelled by the piston per minute on B.

Example.

If the stroke be 8 and the number of strokes per minute 27½ feet, what is the travel of the piston? Ans. 220 feet.

TWIST OF YARN.

RULE.—Bring the number of inches delivered per minute on B to the revolutions of the flyer on A, then over 1 inch on B is the twist per inch on A.

Examples.

1. If you have 400 inches of yarn delivered per minute, and the flyer makes 2200 revolutions per minute, what is the twist of the yarn per inch? Set 400 on B to 2200 on A, and against 1 on B is 5,5 on *A*, the answer.

2. If you have 200 inches of yarn delivered per minute and the flyer makes 1800 revolutions per minute, what is the twist of the yarn per inch? Set 200 on B to 1800 on A, and against 1 on B is 8,5 on A, the answer.

3. If you have 500 inches of yarn delivered per minute and the flyer makes 3000 revolutions per minute, what is the twist of the yarn per inch? Set 500 on B to 300 on *A*, and against 1 on B is 6 on *A*, the answer.

DRAUGHT OF FRAMES.

Rule.—Bring the number of teeth in the driven on B to the number of teeth in the driver on A then under 1 on A is the draught given by these two gears on B, then bring the next driven on B to its driver on A, and look under the draught given by the first two gears on A, and you have the draught given by the first two with the addition of the draught given by the second two on B, then bring the diameter of the front roller in 8-8 on B to the diameter of the back roll on A and under the draught given by the first and second set of gears on A is the whole draught on B.

Example.

The drivers and the driven are as follows, viz: 1st driver 20; 2d, 40; back roller $\frac{7}{8}$. 1st driver 40; 2d, 70; front roller 8-8.

Set 40 on *B* to 20 on *A* then under one inch on A is the draught given by these two gears on B [2]; then bring 70 on B to 40 on A and uuder 2 (the first draught,) on A is the 2d draught on B [3,50] then bring 8-8 on B to $\frac{7}{8}$ on A and under 350 (the 2d draught) on A is the whole draught on B. Answer 4 inches.—*Moulton.*

A TABLE OF GUAGE POINTS,

FOR WEIGHING THE DIFFERENT ARTICLES CONTAINED THEREIN.

	Square.			Cylinder.		Globe.	
	FFF	FII	II	FI	II	F	I
Oak......	174	252	303	320	386	332	578
Mahogany	15	217	2605	276	333	286	49
Box......	155	243	269	31	342	296	512
Red Pine .	242	351	422	458	539	461	805
Marble ...	591	85	102	116	13	113	195
Brick.....	795	115	138	147	176	152	263
Oil.......	174	25	301	319	383	332	574
Bees'Wax	16	231	278	294	355	306	53
Sulphur ..	8	115	138	146	126	153	264
Alcohol ..	193	278	333	354	424	369	637
Air	128	1843	22118	2347	28162	244	42243
Malt bush.	125	179	2150	2276	2738	267	41

Examples.

1. What will a piece of bees' wax weigh that is 10 inches long and 3 inches square? Set 10 on B to 278 on A, then against 3 on D will be 3,22 lbs nearly, on C, the answer.

2. What will a block of marble weigh that is 5 inches long and 2 inches square? Set 5 on B to 102 on A, and against 2 on D will be 1,8 lbs (or 1 lb 12 oz, nearly) on C, the answer.

3. What is the weight of a beam of pine 6 feet long and 9 inches square? Ans. 114 lbs 8 oz.

MISCELLANY.

To find the size of a mast for a ship of a given tonnage.

RULE.—Set 1 on B to 1,5, the guage point, on A, and against the sum of the breadth of the beam and depth of the hold in feet on A, will be the length of the mainmast required, in yards, on B.

Example.

If the beam is 28,5 and the depth of the hold is 12 feet, what is the length of the mast? Ans. 27 yards.

A table of guage points to find the solid contents of shafts and prisms that are polygon sided.

No. of sides.	Guage points.
3	23
5	58
6	385
7	274
8	207
9	161
10	13
11	1063
12	833

RULE.—Set the length on B to the guage point on A, then against the length of one of its sides on D will be the cubic contents in inches on C.

Examples.

1. What are the contents of a triangular prism, the length of which is 24 inches and that of its sides are 12 inches? Set 24 on B to 23 on A, and against 12, the length of one side, on D are 1500 cubic inches on C, the answer.

2. How many cubic inches are contained in a

5 sided body the length of each side of which being 4 inches and its height 12? Set 12 on B to 58 on A, and against 4 on D are 331 inches on C, the answer.

3. What are the contents of a shaft 60 inches long with 8 sides, each of which is 2 inches? Set 60 on B to 277 on A, and against 2 on D are 1160 on C, the answer.

The following guage points are used for finding the cubic feet in shafts that are of polygonal sides. The length of the sides must be equal.

No. of sides.	Guage points.	No. or sides.	Guage points.
3	18,24	8	5,45
4	12,00	9	4,825
5	9,11	10	4,325
6	7,46	11	3,925
7	6,30	12	3,600

Rule.—Bring the length, in feet, on C to the guage point on D, then over the length of one of its sides on D are the cubic feet on C.

RELATIVE STRENGTH OF MATERIALS.

If a beam 2 inches deep and 1 inch broad will support a given weight, another beam of the same depth and double the breadth will support double the weight. Hence beams of the same depth are to each other as their breadths.

Example.

If a beam 4 feet long, 2 inches deep and 1 inch broad supports, without breaking, a weight of 50 lbs, how many pounds will another beam of the

same material and of the same length and depth, with a width or cross section of 3 inches support? Set 1 [inch] on B to 50 lbs on A, and against 3 on B are 150 lbs on A, the answer.

If a beam that is 6 inches deep and 1 inch broad supports a given weight, another beam 4 inches deep and 1 inch broad will support four times the weight of the former—hence beams of equal breadths are to each other as the square of their depths.

Example.

If a beam 12 feet long, 4 inches wide and 3 inches deep supports a weight of 100 lbs without breaking, how many pounds will a beam of the same length and cross section with a depth of 6 inches support? Set 3 on D to 100 on C, then against 12 [inches] on D is 400 lbs on C, the ans.

If a beam of a given cross section 1 foot long, supports a given weight, another beam of the same cross section but double the length [*i. e.* 2 feet long] will support only half the same weight —hence, beams of equal widths and depths are to each other inversely as their lengths.

Example.

If a beam 6 inches square and 2 feet long supports 250 lbs, how many pounds will another beam of the same width and depth but 5 feet long, support? Invert the slider and set 2 on C to 250 on A, then against 5 on C will be 100 lbs on A, the answer.

From the above examples we infer that the strength of beams are directly as their breadths

and square of their depths, and inversely as their lengths—and if cylindrical, as to the cubes of their diameters.

To find the length of one side in miles of a tract of land laid out in the form of an equal square which shall contain as many acres as there are rails in the fence that encloses it.

RULE.—Bring 1 on B to 2, the guage point, on A, then against the number of rails it takes to make one rod of the fence on B will be the length of the required side in miles on A.

Examples.

1. A tract of land is to be laid out in the form of an equal square, and to be enclosed by a post and rail fence so that each rod of fence shall contain 10 rails—how large must said square be to contain just as many acres as there are rails in the fence that encloses it? Set 1 on *B* to 2, the the guage point, on A, then against 10, the number of rails in a rod of fence, on B are 20 miles, the length of one side, on *A*, the answer.

2. What is the length of one side of a tract of land to be laid out as above, and to be enclosed by a post and rail fence 4 rails high, two lengths of which shall make a rod? Set 1 on B to 2, the guage point, on A, then against 8 the number of rails in a rod of fence, on B will be 16 miles, the length of the required side, on *A*, the answer.

If the handle of a pump is 84 inches long, the end to which the bucket is attached is 30 inches from the bolt or fulcrum, and the other end being 54 inches long passes through a space of 19

inches, what will be the stroke of the bucket? Set 54 ou B to 19 on *A*, then against 30 on B will be 10,57 inches on A, the answer.

How many ale, wine and imperial gallons and lbs of water will a pump contain which is 24 feet long, with a barrel 6 inches in diameter, and what power must be applied to the handle, circumstanced as in the last example, to work it, aside from the friction, for water? Set 24 [feet] on B to the several guage points [found in the table on the Rule, against the given names] viz: for ale 229, for wine 245, and for imperial 294, on **A**, then against 6, the diameter, on D are 28,8, 35,5 and 29,5 gallons, respectively, on C. Now since an imperial gallon of water weighs 10 lbs, the weight of water would be 295 lbs; consequently, to find the power requisite to work the pump for water, invert the slider and set 30, the shorter end, on C to 295 on A, then against 54, the longer end, on C are 164 lbs on *A*, the answer.

To find the contents of a square figure in yards when its dimensions are given in feet.

Rule.—Set the number of feet contained in a yard (viz. 9) on B to the width in feet on A, then against the length in feet on B will be the contents in yards, &c. on A.

Example.

What are the number of yards contained in a piece of plastering 42 feet long and 18½ feet high? Ans. 39⅓ yards.

Remark.—The contents of a square in feet when the dimensions are given in inches is ascertained by setting 144 on B to the width in inches on A, then proceed as in the example.

TRIANGLES.

Every plane triangle* has six parts, three angles and three sides; the longest of which in an oblique angled triangle is usually taken for the base, which, for the sake of reference, is designated as the side AB, the other two sides are called the sides AC and BC respectively, which letters are placed at the intersection of the several sides with each other; the angles also are designated by the same letters, thus: the angle formed by the intersection of the side AB with the side AC is designated as the angle A, or, as it is sometimes expressed, BAC, (the middle letter in such cases always expressing the angle to which reference is made) and the angle formed by the intersection of the side BC with the side CA is designated as the angle C, or BCA, and the angle formed by the side AB with the side BC as the the angle B, or ABC.

There are two kinds of triangle, *right angled triangles* and *oblique angled triangles*, The former of these (viz. the right angled triangle) always contains one right angle, or 90 degrees; the latter (viz. the oblique angled triangle) never contains a right angle, each angle being more or less than 90 degrees. The longest side of a right angled triangle is called the hypothenuse, and the other two, the legs or the base and perpendicular. The

* Plane triangle is used in contradistinction to spherical triangle.

sum of all the angles of any triangle is always 180 degrees, consequently if any two angles of a triangle are known the other angle may be found by subtracting their sum from 180; thus, if the sum of two angles of a triangle is known to be 110 degrees, the remaining one would be 70 degrees. As one angle of a right angled triangle is always 90 degrees, and is never mentioned as one of the given angles, the unknown angle may be ascertained by subtracting the given angle from 90, the half of 180; thus, if one angle of a right angled triangle was known to be 35 deg. the other could be found by subtracting 35 from 90 deg. which would be the same as subtracting 125 [the sum of 90 and 35] from 180 deg. namely 55 deg.

In finding the sides of a triangle from its angles and *vice versa*, three parts must be known, which must be one side and two angles, or two sides and the angle opposite one of them. In right angled triangles the right angle is always considered as one of the given angles; consequently the sides of a right angled triangle may be ascertained when one of the two expressed angles [A and C] are given together with the side opposite the given angle.

There are three cases of right angled triangles and one of oblique angled triangles for the solution of which we have the following table of guage points.*

* There are four cases of right angled and four of oblique angled triangles: three of the first and one of the latter will only be treated of here.

DESCRIPTION OF THE TABLE.

The column on the left hand marked *degrees* contains the degrees in a given angle from 1 to 45, which reads down the page in the usual manner, with their respective guage points in the first division of the column marked Col. 1st—the second division of which contains the guage points for half degrees or 30 minutes. Col. 2d also contains guage points for the same degrees and minutes, and may be used when the given angle and the required side of a right angled triangle are adjacent, the required side being one of the sides that form the right angle; the column on the right hand marked *degrees*, at the bottom of the page, contains the degrees from 46 to 89, which read up the page instead of down, with their guage points in their respective columns like those before described, with the exception that the guage point for degrees are in the division on the left of the column marked 30′ instead of being on the right. It must be observed, however, that when the guage point for 30 minutes of any degree between 45 and 90 is required, it will be found in its appropriate column against the first degree above the given one; thus if the guage point for 71 deg. 30 min. is required it will be found against 72 deg. in column 30′ to be 948.

A TABLE OF GUAGE POINTS FOR FINDING THE SIDES OF A TRIANGLE FROM ITS ANGLES, AND VICE VERSA.

Degrees	Col. 1st		Col. 2d			Degrees	Col. 1st		Col. 2d		
		30'		30'				30'		30'	
1	174	262	999	999	89	24	407	415	9135	909	66
2	349	436	999	999	88	25	423	43	906	902	65
3	523	610	998	998	87	26	438	446	899	895	64
4	697	784	997	996	86	27	454	462	891	887	63
5	871	953	996	995	85	28	469	477	883	879	62
6	101	113	994	993	84	29	485	492	875	87	61
7	122	13	992	991	83	30	5	507	866	862	60
8	139	148	99	989	82	31	515	522	857	853	59
9	156	165	987	986	81	32	53	537	848	843	58
10	173	182	985	983	80	33	543	552	839	834	57
11	191	199	981	979	79	34	559	566	829	824	56
12	208	216	978	976	78	35	573	58	819	814	55
13	225	233	974	972	77	36	588	595	809	804	54
14	242	25	97	968	76	37	602	609	799	793	53
15	259	267	966	963	75	38	616	622	788	783	52
16	275	284	961	958	74	39	629	636	777	772	51
17	292	3	956	953	73	40	643	649	766	76	50
18	309	317	951	948	72	41	656	663	755	749	49
19	325	338	945	942	71	42	669	675	743	737	48
20	342	35	939	937	70	43	682	688	731	725	47
21	358	366	933	93	69	44	695	7	719	713	46
22	375	383	927	924	68	45	707	713	707	7	
23	39	399	92	917	67						
		40'		30'	Degrees			30'		30'	Degrees
	Col. 2d		Col. 1st				Col. 2d		Col. 1st		

RIGHT ANGLED TRIANGLES.

CASE FIRST.

The angles and hypothenuse given to find the legs.

RULE.—Set 1 on B to the hypothenuse, or longest side, on A, then against the guage point (found in col. 1st) of the given angle on B will be the length of the side opposite that angle on A.

Examples.

1. In a right angled triangle ABC, the angle at A is 35° 30′, consequently the angle at C is 54° 30′, and the hypothenuse AC is 25 rods, what is the length of the two legs AB and BC? Set 1 on B to 25, the hypothenuse, on *A*, then against 58, the guage point for 35° 30′ (found in division marked 30′ of col. 1st, opposite 35 in the column of degrees) on B will be 14,52 rods for the perpendicular BC (which is the leg opposite the given angle) on A, and against 824, the guage point for the angle 54° 30′ (found in col. 1st, division 30′, against 55 in the column of degrees) on B is 20,35 rods on *A* for the leg or side opposite the angle C, the answer.

2. In a right angled triangle ABC, the hypothenuse AC is given 125 rods, the angle at A 46° 30′ (which subtracted from 90 gives the angle at C 43° 30′) what is the length of the sides AB and BC? Set 1 on B to 125 rods on *A*, then against 725, the guage point, (found in col. 1st, div. 30, against 47 in col. degrees) on B is 181,4 rods, the length of the side BC on A; and against 688, the guage point, (for the angle 43 30′ =to the angle

C) on B are 172,1 rods, the angle of the side AB, on A, the answer.

CASE SECOND.

The angles and base given to find the perpendicular and hypothenuse.

RULE 1st, to find the hypothenuse.—Set the guage point of the angle opposite the given leg on B to the length of the given leg or base on A, then against 1 on B will be the length of the hypothenuse on A.

2d, to find the perpendicular.—Set the guage point of the angle opposite the base or given leg on B to the base or given leg on A, then against the guage point of the angle opposite the perpendicular or required leg on B will be the length of the perpendicular or required leg on A.

Example.

In a right angled triangle ABC, the angle A is 33°, consequently the angle at C is 57° and the base is 325 rods, what is the length of the hypothenuse and perpendicular? Set 839 the guage point for the angle 57°, (found in col. 1s, left hand division, against 57 in the column of degrees) on B to 325, the length of the base or opposite side, on A, then against 1 on B will be 388,6 rods, the length of the hypothenuse, on A; and against 543, (the guage point for 33°, the angle at A,) on B will be 213,1 rods, the length of the perpendicular, on A, the answer.

CASE THIRD.

The angles and perpendicular given to find the base and hypothenuse.

RULE 1st, to find the hypothenuse.—Set the

guage point of the angle A on B to the length of the perpendicular on A, then against 1 on B will be the length of the hypothenuse on A.

2d, to find the base.—Set the guage point of the angle A on B to the side BC on A, then against the guage point of the angle C on B will be the length of the base AB on A.

Example.

In a triangle ABC, the angle A is 40°, consequently the angle C is 50, and the perpendicular BC 17 rods, what is the length of the hypothenuse AC, and the base AB? Set 643, the guage point of the angle A, on B to 17 (rods) on A, then against 1 on B are 26,45 rods on A, the length of the hypothenuse AC; and against 766 (the guage point for 50°) on B are 20,26 rods, the length of the perpendicular BC, on A, the answer.

OBLIQUE ANGLED TRIANGLES.

CASE FIRST.

The angles and one side given to find the other side.

Rule.—Set the guage point of the angle opposite the given side on B to the given angle on A, then against the guage point of the angle opposite of either of the required sides on B will be the side opposite that angle on A.

Example.

In an oblique angled triangle ABC, the angle at B is 48°, the angle at C is 72°; the sum of which taken from 180 gives for the angle at A 60°, and the base AB is 200 rods—what is the height of the sides AC and BC? Set 951 (the

guage point of 72°, the angle at C) on B to 960 on A, then against 743, the guage point of 48°, on B are 156 rods, the length of the side AC, on A; and against 866, the guage point of 60°, on B are 182 rods, the length of the side BC, on A, the answer.

To find the hypothenuse of a right angled triangle when the base and perpendicular are equal.

Rule.—Set 1 on B to 1,141 on A, then against the length of the base or perpendicular on B will be found the hypothenuse on A.

Examples.

1. If the base and perpendicular are each 36 inches, what is the hypothenuse? Set 1 on B to 1,141 on A, and against 36 on B will be found 50,92 on A, the answer.

2. If the base and perpendicular are each 51 inches what is the other side? Set 1 on B to1,141 on A, (the guage point given in the rule) and against 51 on B will be found 72,12 inches on A, the answer.

Remark.—As the slider now stands, against any number of inches on B will be found the answer in inches on A; or, calling the number feet, will be found the answer in feet and decimals of a foot on A.

3. What is the hypothenuse of a right angled triangle whose base and perpendiular are each 60 feet? Set the slider as in the former examples, then against 60 on B will be found the answer, 84,85 feet, on A. Or, call 6 on B 6 feet, and against 6 on B will be found 8,485 feet on A,

which is the length of a brace whose base and perpendicular are each 6 feet.

HEIGHTS AND DISTANCES.

It will be readily seen that problems relating to heights and distances can in many cases be solved by the foregoing rules for triangles: for unknown heights and distances can be ascertained only when they correspond to the unknown sides of either a right or an oblique angled triangle, and the angles of elevation or depression, and the bearings of inaccessible objects correspond to the given angles.

Examples.

1. What is the height of a steeple when the angle of its spire, taken on a plane beneath 85 feet from its base, is 53 deg? Set the guage point 370 (the angle at the top of the spire, found by subtracting 53 from 90°) on B to 85 [feet] on A, and against the guage point of 53° on B will be 112,8 feet on A, the height of the steeple.

Remark.—The height of the observer's eye must be added to the result of the calculation to get the true height of the object: thus—in the above example, if the height of the eye above the base of the steeple were 5 feet, it should be added to 112,8, which makes the true height of the steeple above the ground to be 117,8 feet.

2. At 170 feet distance from the bottom of a tower, the angle of its elevation was found to be 52° 30′, what was the height of the tower? Ans. 221,55 feet.

3. Being on the side of a river and wishing to know the distance to a house which was seen on the opposite side, I measured out for a base 400 yards in a right line by the side of the river and found that the two angles at each end of this line subtended by the other end and the house, were 68° and 70°, what was the distance of the house from each station?

Ans. $\begin{cases} 593 \\ 612 \end{cases}$ yards, nearly.

If the extreme end of the minute hand of a clock should be observed to move forward at the rate of 30 inches in 5 minutes, what will be the circumference of that part of the dial plate, and likewise the length of the minute hand? Set 5 minutes upon B to 30 inches upon A, and against 60 minutes upon B [that being one revolution of the hand] stands 360 inches, the circumference of the dial, upon A; then set 1 upon B to 3,14 upon A, and against 360 upon A are 11,58 inches, the diameter of the dial plate, which divided by 2 gives the length of the minute hand, equal to 57,29 inches.

If a man sets out from Bolton to London and walks at the rate of 3 miles an hour—another man at the same time sets off from London to Bolton and walks at the rate of 3½ miles an hour, at what distance from each place will they meet, it being

193 miles between the two towns? *Add* 3 to 3½, equal 6,5 or 6½, then set 6,5 upon B [the distance they both walk in an hour] to 193 miles upon *A*, and against 3 upon B are 89 miles upon *A*. the distance from Bolton, and against 3,5 upon B are 104 miles upon *A*, the distance from London.

Note.—The horse power of a steam engine may be found by setting 5 on B to 9 on A, then against the diameter of the cylinder in inches on D will be the horse power on C—the lines D and C thus forming a table of diameters of cylinders and horse powers.

Note.—In the description of the table on the Engineer's Rule, (page 121) it is stated that it is "used entirely for measuring and weighing *solid* bodies." This is a mistake. There are guage points for measuring superfices, and also on the same leg tables of guage points for polygons, pumping engines, and circles, which are fully explained in the body of the work.

A TABLE,

Giving the number of feet of inch boards that can be sawed from any log of given dimensions.

Diameter \ Length	9	10	11	12	13	14	15	16
12	55	61	67	73	79	85	91	97
13	65	72	79	86	93	100	107	114
14	75	83	92	100	108	116	125	133
15	86	96	105	115	125	134	144	154
16	98	109	120	131	142	153	164	175
17	110	122	134	147	159	171	184	196
18	124	137	151	165	179	192	206	220
19	138	153	169	187	199	215	230	245
20	153	170	187	204	221	238	255	272
21	169	187	206	225	244	262	281	300
22	185	206	226	247	268	288	309	329
23	202	225	247	270	292	315	337	360
24	220	245	269	294	318	343	367	392
25	239	266	292	319	346	372	399	425
26	258	287	316	345	373	402	431	460
27	279	310	341	372	403	434	465	496
28	300	333	367	401	433	467	500	533
29	322	357	393	429	464	500	536	572
30	344	382	421	459	497	535	574	612
31	367	408	449	490	531	572	612	653
32	391	435	478	522	565	609	652	696
33	416	462	509	555	601	647	694	740
34	442	492	541	590	639	688	737	787
55	469	521	573	625	677	729	781	833
36	496	551	606	661	716	771	826	881
37	524	582	640	698	756	814	872	931
38	552	613	675	736	797	859	920	981
39	582	647	711	776	841	905	970	1035
40	612	680	748	816	884	952	1020	1088

Example.

How many feet of inch boards can be sawed from a log 10 feet long and 20 inches in diameter? Under 10 and against 20 we have 170 feet, the answer.

DIRECTIONS FOR SELECTING A RULE.

As it is of the utmost importance to have an Instrument accurately divided, this should be the first consideration in selecting a Rule; to determine which, all that is necessary is to perform some simple problem, such as multiplying 5, 6, 7, 8, &c. by 2 or 3, and if the proper divisions exactly coincide it may be relied upon for accuracy, but if there is the least variance it will be of little or no use as an instrument of calculation. The accuracy of the Girt Line may be determined by extracting the square root of any convenient number.

The lines E and M are used for reducing a beam of four equal sides to one of eight, which is performed as follows: If the beam to be reduced be eight inches square, set one foot of a pair of dividers at 1 on the line E and extend to 8—this distance set off from the "corners" on the adjacent sides of the beam will form points, which being united by lines drawn on the end of the

beam will give the required dimensions of the eight-sided beam. Or, set one foot at 1 on the line M and extend the other to 8—this distance laid off from the middle of the four square beam on each of its sides will give the points of intersection of the sides of the eight-sided beam, as before.

Remark.- This operation also determines the dimensions of the greatest octagon sided beam that can be cut from a given one of four equal sides.

CONTENTS.

THE END.

PUBLISHER'S NOTICE.